Issued September 23, 1912.

U. S. DEPARTMENT OF AGRICULTURE,
FOREST SERVICE—BULLETIN 108.
HENRY S. GRAVES, Forester.

FOREST PRODUCTS LABORATORY SERIES.

TESTS OF STRUCTURAL TIMBERS.

BY

McGARVEY CLINE,
Director, Forest Products Laboratory,
AND
A. L. HEIM,
Engineer in Forest Products.

WASHINGTON:
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FOREST SERVICE.

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ALBERT F. POTTER, *Associate Forester.*
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LETTER OF TRANSMITTAL.

U. S. Department of Agriculture,
Forest Service,
Washington, D. C., March 18, 1912.

Sir: I have the honor to transmit herewith a bulletin entitled "Tests of Structural Timbers," by McGarvey Cline, Director Forest Products Laboratory, and A. L. Heim, Engineer in Forest Products, and to recommend its publication as Bulletin 108 of the Forest Service.

Respectfully,

Henry S. Graves,
Forester.

Hon. James Wilson,
Secretary of Agriculture.

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TESTS OF STRUCTURAL TIMBERS.

PURPOSE OF THE TESTS.

This bulletin aims to correlate all the tests which have been made by the Forest Service on structural timbers, exclusive of round timbers and other special forms. The results given should be of use—(1) in determining working stresses and proper factors of safety in connection with the design of timber structures; (2) in studying the relation of the physical characteristics and defects of timber to its strength and other mechanical properties; and (3) in devising standard specifications and grading rules for different forms of structural timbers, along which line much valuable work has already been done by the American Society for Testing Materials and the American Railway Engineering Association.

No attempt has been made to recommend the factors of safety which should be applied to the values given in the tables, but a complete analysis of the variation of individual results is presented, and the matter left to the judgment of engineers.

The aim has been to make the text of the bulletin serve as a guide to the study of the diagrams and tables rather than as an exhaustive treatise on the subjects taken up. This brevity has permitted the use of more complete diagrams and tables than has been possible in previous publications of the Forest Service dealing with timber tests. The Appendix contains complete descriptions and test data of the timbers tested.

The tests covered by this bulletin were begun in 1903 by Dr. W. K. Hatt, at that time Chief of the Section of Timber Tests of the Bureau of Forestry, and were conducted under his general supervision until 1907, since which time he has been connected with the work in a consulting capacity. Prior to the establishment of the Forest Products Laboratory in cooperation with the University of Wisconsin, in 1909, the tests were carried on at laboratories conducted in cooperation with Purdue University, Yale Forest School, University of Oregon, University of California, University of Washington, and the University of Colorado. Since 1909 cooperation with all of these laboratories, except those at the University of Washington and the University of Colorado, has been discontinued, and the timber-test work centralized at the Forest Products Laboratory at Madison, Wis.

The tests to determine the mechanical properties of commercial timbers of the United States carried on there may be divided into four general series: Series 1, standard tests of small specimens free

from defects; series 2, tests of structural timbers; series 3, tests to determine the effect of different commercial treatments; and series 4, tests on manufactured articles. The results of these tests are published by the Forest Service in bulletins and circulars. General summaries of the results of tests on structural timbers have appeared in Forest Service Circulars 32, Progress Report on the Strength of Structural Timber, and 115, Second Progress Report on the Strength of Structural Timber. Results of tests on particular species have been published in Bulletin 88, Properties and Uses of Douglas Fir, and Circular 164, Properties and Uses of the Southern Pines. Similar publications giving the results of tests on western larch, western hemlock, and redwood are now in preparation. Other publications give the results of tests classed as series 1, 3, and 4.

MATERIAL TESTED.

Strength and durability are, of course, essential in timbers used for structural purposes, but the ability to secure wood in the sizes required, and the cost of the material delivered, often determine what species are used in any specific case. Often local wood will not only serve the purpose of the engineer as well as wood transported from a distance, but can be secured in better grades and at lower prices. In such cases the local material will very likely be used, provided authentic information regarding its properties is available. Without such information, however, the tendency of the builder is to use a wood with which he is more familiar. In selecting timbers for test these facts were borne in mind, and a number of species at present little used for structural purposes are included.

The species tested may be classified as follows: [1]

---

[1] The common names used in this bulletin for the various species mentioned are those adopted by the Forest Service. Following is a list of other common names applied to these species:

Longleaf pine (*Pinus palustris*).—Southern, yellow, turpentine, rosemary, brown, hard, Georgia, fat, southern yellow, southern hard, southern heart, southern pitch, heart, pitch, longleaved yellow, longleaved pitch, North Carolina pitch, Georgia yellow, Georgia heart, Georgia longleaved, Georgia pitch, Florida yellow, Florida, Florida longleaved, Texas yellow, and Texas longleaved pines.

Shortleaf pine (*Pinus echinata*).—Yellow, shortleaved spruce, shortshat, pitch, bull, poor, shortleaved yellow, rosemary, Virginia yellow, North Carolina yellow, North Carolina, Carolina, slash, and oldfield pines.

Loblolly pine (*Pinus tæda*).—Oldfield, torch, rosemary, slash, longschat, longshucks, black slash, frankincense, shortleaf, bull, Virginia, sap, meadow, cornstalk, black, foxtail, Indian, spruce, bastard, yellow, swamp, longstraw pines.

Douglas fir (*Pseudotsuga taxifolia*).—Red fir, Douglas spruce, yellow fir, spruce fir, Oregon pine, red pine, Puget Sound pine, Douglas-tree, cork-barked Douglas spruce.

Western hemlock (*Tsuga heterophylla*).—Hemlock spruce, western hemlock spruce, hemlock, California hemlock spruce, western hemlock fir, Prince Albert's fir, Alaska pine.

Western larch (*Larix occidentalis*.—Tamarack, hackmatack, larch, red American larch, western tamarck, great western larch, and western larch.

Redwood (*Sequoia sempervirens*).—Sequoia, coast redwood, California redwood.

Norway pine (*Pinus resinosa*).—Red pine, hard pine, and Canadian red pine.

Tamarack (*Larix laricina*).—Larch, hackmatack, American larch, juniper, black larch, epinette rouge, ka-neh-tens (the leaves fall), red larch, hacmack.

Red spruce (*Picea rubens*).—Yellow spruce, North American red spruce.

White spruce (*Picea canadensis*).—Single spruce, bog spruce, skunk spruce, cat spruce, pine, spruce, double spruce.

Southern yellow pines:
- Longleaf pine (*Pinus palustris*).
- Shortleaf pine (*Pinus echinata*).
- Loblolly pine (*Pinus tæda*).

Timbers of the Pacific coast:
- Douglas fir (*Pseudotsuga taxifolia*).
- Western hemlock (*Tsuga heterophylla*).
- Western larch (*Larix occidentalis*).
- Redwood (*Sequoia sempervirens*).

Timbers of the New England and Lake States:
- Norway pine (*Pinus resinosa*).
- Tamarack (*Larix laricina*).
- Red spruce *Picea rubens*).
- White spruce (*Picea canadensis*).

The botanical and commercial range of these species is shown in Plates I, II, and III. The region in which each is principally manufactured into lumber is indicated by the darker areas. The maps show at a glance the sources of supply of the different species, and should aid the user of structural timber in deciding which species can be used most advantageously at any particular point.

SOUTHERN YELLOW PINES.

The term "southern yellow pine" is applied collectively to practically all of the pines of the Southern States which are manufactured into lumber. On the market the manufactured lumber is divided into two classes, longleaf and shortleaf. Material with more than 8 or 10 rings per inch, and containing a comparatively large amount of summerwood and less than 30 per cent of sapwood, is called longleaf pine; while material with fewer than 10 rings per inch, slow-growing material that is light in weight, and which contains much sapwood, is called shortleaf pine. Commercially, therefore, the terms "longleaf" and "shortleaf" are descriptive of quality and have little botanical significance.[1]

The southern yellow pines furnished approximately one-third of the entire lumber output of the United States in 1910. The bulk of the material manufactured is made up of three species, longleaf pine (*Pinus palustris*), shortleaf pine (*Pinus echinata*), and loblolly pine (*Pinus tæda*). The greater part of the loblolly pine manufactured into lumber, especially on the Atlantic coast, is sold in New York, Philadelphia, and other eastern markets as North Carolina pine.

Longleaf pine (*Pinus palustris*).

A part of the longleaf pine tested was furnished by the E. P. Burton Lumber Co., Charleston, S. C., and was cut from its holdings on the Cooper River, 40 miles from Charleston. The remainder was furnished by the Illinois Central Railway Co. from stock on hand at

[1] See "Standard specifications for structural timbers," American Society for Testing Materials.

Grenada, Miss. This material was doubtless cut at some point in Mississippi or Louisiana tributary to the lines of the company.

Shortleaf pine (Pinus echinata).

The shortleaf pine was furnished by the Yellow-Pine Manufacturers' Association, and was cut on the holdings of the Wisconsin & Arkansas Lumber Co. near Malvern, Ark.

Loblolly pine (Pinus tæda).

The loblolly pine was furnished by the E. P. Burton Lumber Co. from their holdings in South Carolina.

TIMBERS OF THE PACIFIC COAST.

Douglas fir (Pseudotsuga taxifolia).

Douglas fir is the most important timber of the Northwest, and is more extensively used for structural purposes than any other single species. In the production of lumber it ranks second to the southern yellow pines. Dimension timbers find a market throughout the Great Lake Region and as far east as the Atlantic seaboard, for mining, dock, and dredging work, and for spars. The timber is exported to the west coast of South America, Australia, China, Japan, Philippine Island, and South Africa, and has been extensively used in construction work on the Panama Canal. The material tested was furnished by the Oregon & Washington Lumber Manufacturing Association, Portland, Oreg., and the Pacific Coast Lumber Manufacturing Association, Seattle, Wash.

Western hemlock (Tsuga heterophylla).

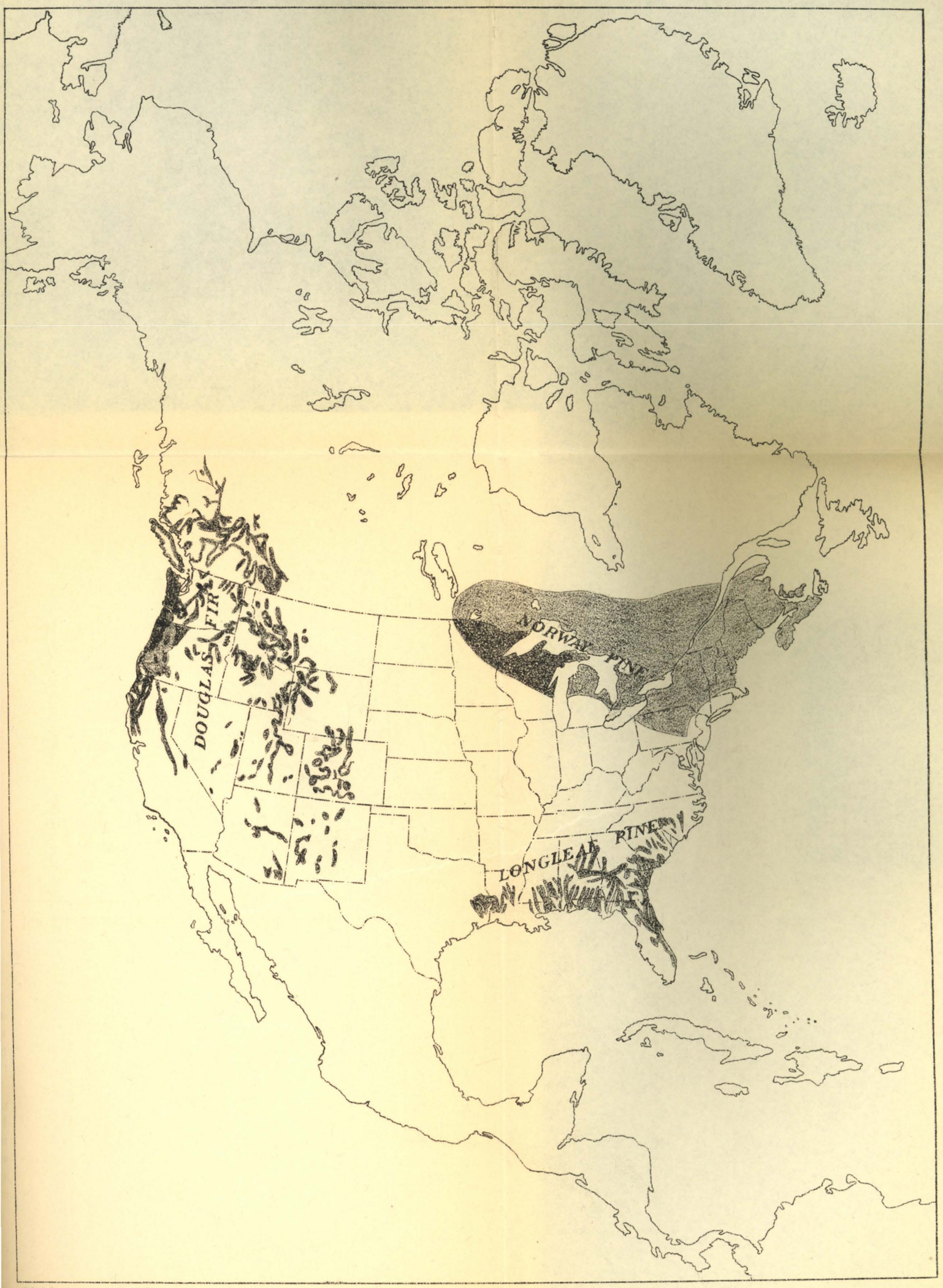
Western hemlock is not, at present, much used for structural purposes. It generally grows with Douglas fir and other timber trees common to the Northwest, and considerable quantities go to market mixed with Douglas fir. The material tested was furnished by the Pacific Coast Lumber Manufacturing Association, Seattle, Wash., and was cut on the holdings of the Western Lumber Co., in the Grays Harbor region, and of the St. Paul & Tacoma Lumber Co., near Buckley, Wash.

Western larch (Larix occidentalis).

Western larch has not yet won a very important place among structural timbers. It has a limited range and will probably not be able to compete with the yellow pines and Douglas fir outside of the region in which it grows. The material tested was furnished by the Western Yellow Pine Manufacturers' Association, Spokane, Wash., and was cut on the holdings of the Phœnix Lumber Co. in Stephens County, Wash.

Redwood (Sequoia sempervirens).

Redwood is one of the most desirable species from which heavy structural timbers may be secured, and the wood is also very slow burning. The bulk of the material is cut in Humboldt and Men-



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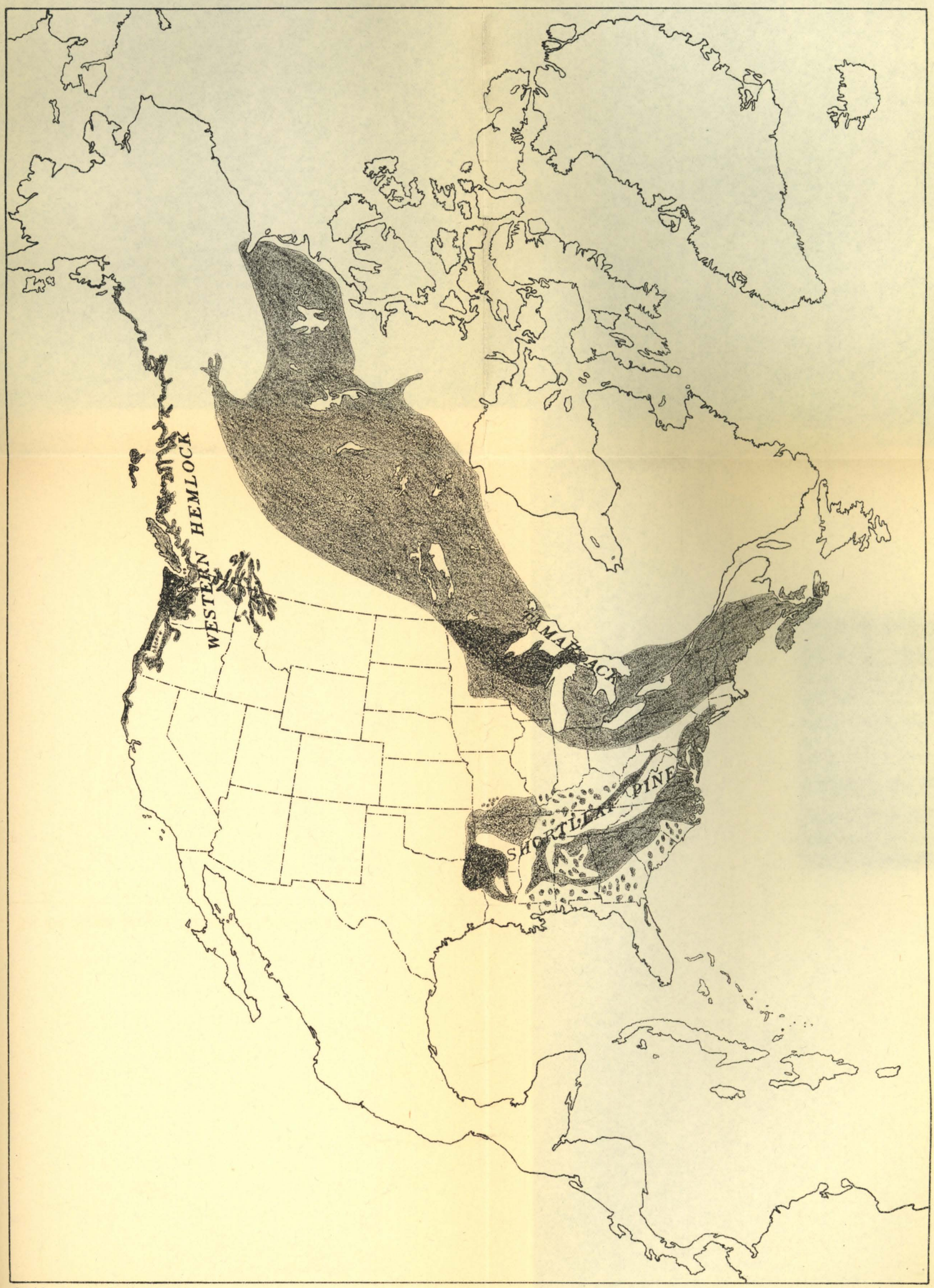

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docino Counties, Cal. It is shipped in cargo lots to San Francisco and southern California points and is distributed through these ports. Considerable quantities are also shipped to Mexico, Central America, South America, the Hawaiian Islands, Australia, and other ports.

TIMBERS OF THE NEW ENGLAND AND LAKE STATES.

Norway pine (Pinus resinosa).

Norway pine at one time was an important timber of commerce much used in construction work, but with the depletion of the northern forests it has been replaced almost entirely by wood from the southern forests and from the Northwest. This species is still available in small quantities, however, and is used to some extent in the Lake States for structural purposes. The material tested was furnished by the Kettle River Quarries Co.[1] and was cut in St. Louis County, Minn.

Tamarack (Larix laricina).

Tamarack, like Norway pine, is at present a structural timber of minor importance and is used only locally in the northern States. The material tested was furnished by the Kettle River Quarries Co.[1] and was cut in St. Louis County, Minn.

Red spruce (Picea rubens) and white spruce (Picea canadensis).

Red and white spruce are used in the New England and, to a certain extent, in other of the Eastern States, for joists and small forms of structural timbers. These species, however, have a high value for paper pulp, and as structural timbers will doubtless never be of more than local importance. The material tested was furnished by the Berlin Mills Co. and was cut in Coos County, N. H.

METHODS OF TEST.

A complete description of the methods of test employed by the Forest Service on structural timbers is given in circular 38.[2] It seems well, however, to include a brief description of the different tests in this bulletin, since it will aid the reader in attaching the proper significance to the results presented. The formula used in calculating the different results contained in the tables will be found in the Appendix (p. 69).

---

[1] Now the Kettle River Co.

[2] "Instructions to Engineers of Timber Tests, Revised." Information in regard to the market conditions, prices, etc., of the species mentioned may be obtained from the secretaries of the lumber manufacturers' associations supplying them. Some of the principal associations of manufacturers of the species discussed in this bulletin are:

Name of association.	Address of secretary.
Yellow Pine Manufacturers' Association	St. Louis, Mo.
Oregon and Washington Lumber Manufacturing Association	Portland, Oreg.
Pacific Coast Lumber Manufacturing Association	Seattle, Wash.
Western Yellow Pine Manufacturing Association	Spokane, Wash.
Redwood Manufacturers' Association	San Francisco, Cal.
Northern Hemlock and Hardwood Manufacturing Association	Wausau, Wis.

BENDING TESTS.

STRINGERS AND HEAVY JOISTS.

Plate IV, figure 1, shows the method used for bending tests on large beams. The testing machines are all provided with an extention weighing platform. The beam is placed on two knife-edge supports, *AA*, which rest on this platform. The load is applied at two points, *BB*, one-third as far apart as the distance between the knife-edge supports. As the head of the screw press, *C*, moves down, the straining beam, *D*, bears with increasing force on the specimen under test. As the load increases the beam deflects. A fine wire, *EE*, kept taut by a spring, is strung between two small nails driven midway between the top and bottom faces of the beam vertically above the knife-edge supports. This wire crosses the face of a steel scale *F*, fastened to the beam midway between the supports. As the beam deflects the scale moves down, while the wire does not change its original position. The distance the scale moves relative to the wire indicates the amount of deflection or bending. This method gives deflection to one-hundredth of an inch, which is sufficiently accurate for tests on structural sizes. The load deformation readings are recorded as indicated in figure 1, and the load at elastic limit is determined by drawing a straight line through the greatest possible number of points, the point at which the curve departs from the straight line being taken as the load at elastic limit. This method of locating the elastic limit is clearly indicated in the figure.

LIGHT BUILDING JOISTS.

Tests on light building joists are essentially the same as those on stringers and heavy joists, except that supports are provided for keeping the joints in a vertical position during test. The character of these supports is shown in Plate IV, figure 2.

SMALL CLEAR BEAMS.

In tests on small clear beams the load is applied at the center of the span, and a special deflectometer is used for measuring deflections to the nearest one-thousandth of an inch. A small beam under test is shown in Plate V, figure 1.

COMPRESSION PARALLEL TO GRAIN.

Plate V, figure 2, shows the method of making tests in compression parallel to grain. The ends of the specimen are carefully squared, and it is then placed, with the grain vertical to the base of the machine, upon a flat block, having a ball-and-socket joint, which rests upon the weighing table of the machine. In tests where the modulus of

elasticity is desired, two yokes are placed on the specimen a specified distance apart. The load is applied by moving the crosshead down at a very slow rate of speed. The decrease in length between the yokes is measured by means of two deflectometers, which are clearly shown in the illustration. The average of the readings given by the two deflectometers is used in plotting the stress-strain diagram. Figure 1 shows a typical diagram for tests in compression parallel to grain. The load at elastic limit is located in the same manner as described for the tests on beams.

COMPRESSION PERPENDICULAR TO GRAIN.

Plate VI, figure 1, shows the method of making tests in compression perpendicular to grain. In these tests the specimen is so placed that the grain is horizontal or parallel to the base of the machine. A steel plate of specified width is adjusted on top of the specimen. The moving crosshead of the machine descends upon this plate, and the amount of deformation produced by a given load is indicated by the deflectometers, which are set up on opposite sides of the specimen. One of them can be seen in the illustration. Text figure 1 shows a typical load-deformation diagram for tests in compression perpendicular to grain. This diagram also shows the method of correcting deflections for loads below the load at elastic limit when the straight-line portion of the curve does not pass through the origin. The corrected deflections are used in calculating the modulus of elasticity.

SHEARING TESTS.

The method of making shearing tests used by the Forest Service is indicated in Plate VI, figure 2. The block to the left shows the test specimen prepared with a projecting tongue which is to be sheared off parallel to the grain. The body of the block is held firmly in the shearing tool by means of set screws, the movable plunger bearing on the projecting tongue. When the specimen is in place the shearing tool is placed in the testing machine and the load is applied to the specimen by means of the plunger. The maximum load is the quantity desired in this test.

MOISTURE CONTENT AND RATE OF SEASONING.

To determine how the strength of structural timber is affected by air seasoning a part of each shipment of material was thoroughly air seasoned before being tested. The moisture distribution in the green and air-dry material is shown in text figure 2, in which the moisture content is given as a per cent of the dry weight of the wood. The values were obtained from disks, 1 inch thick, cut from the

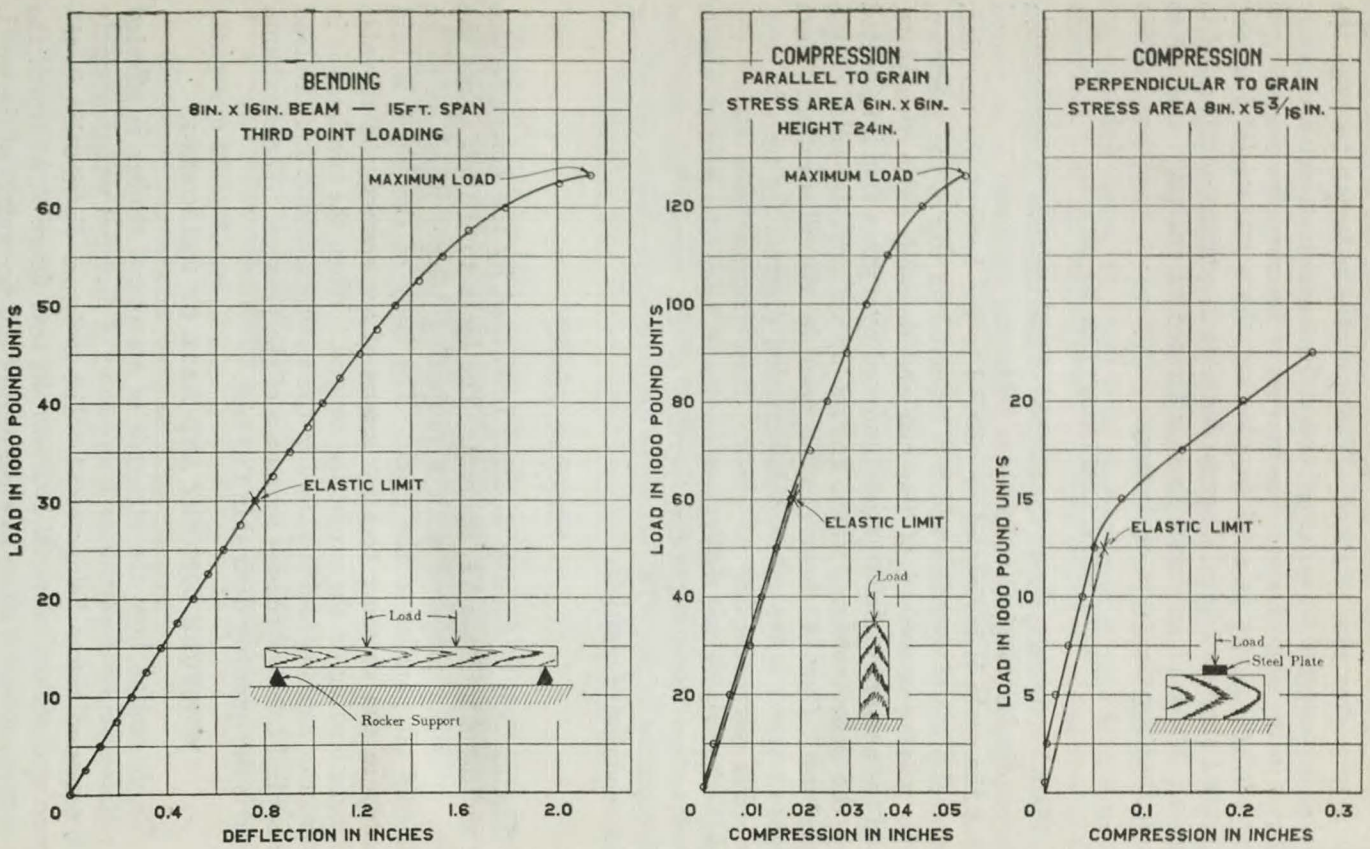


FIG. 1.—Stress strain diagrams for bending compression parallel to grain and compression perpendicular to grain.

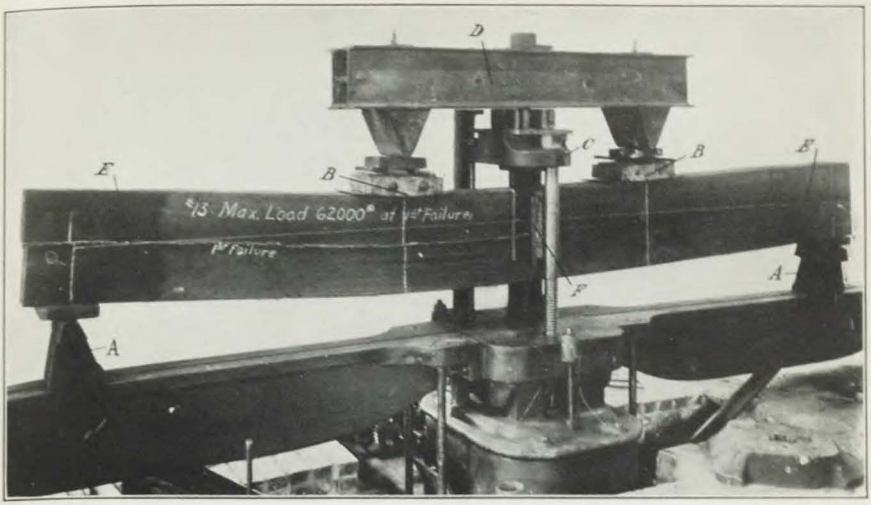


FIG. 1.—METHOD OF TESTING LARGE BEAMS.

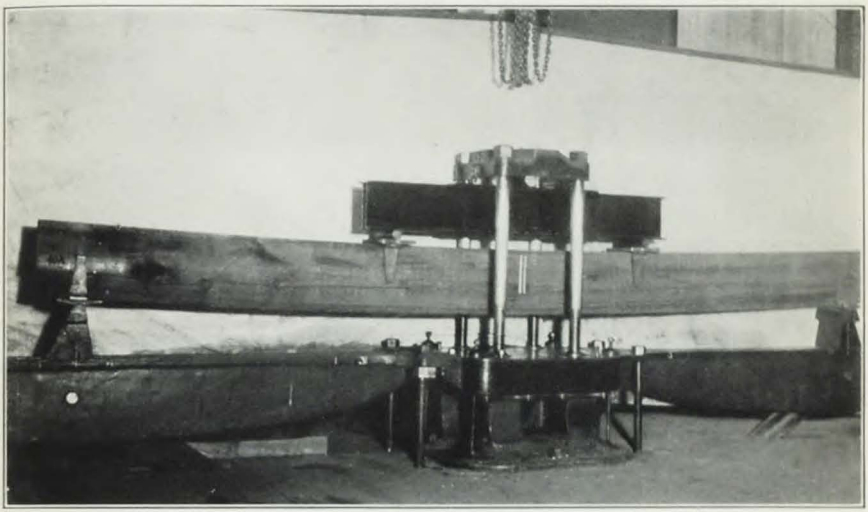


FIG. 2.—METHOD OF TESTING JOISTS.

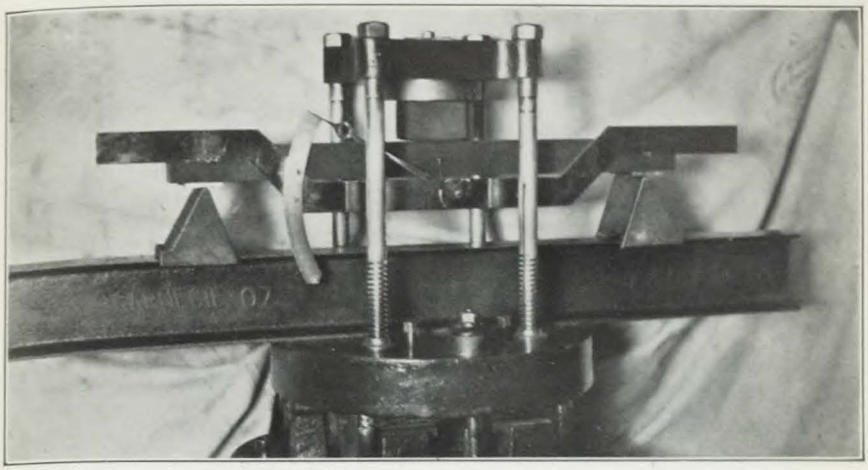


FIG. 1.—METHOD OF TESTING SMALL BEAMS.

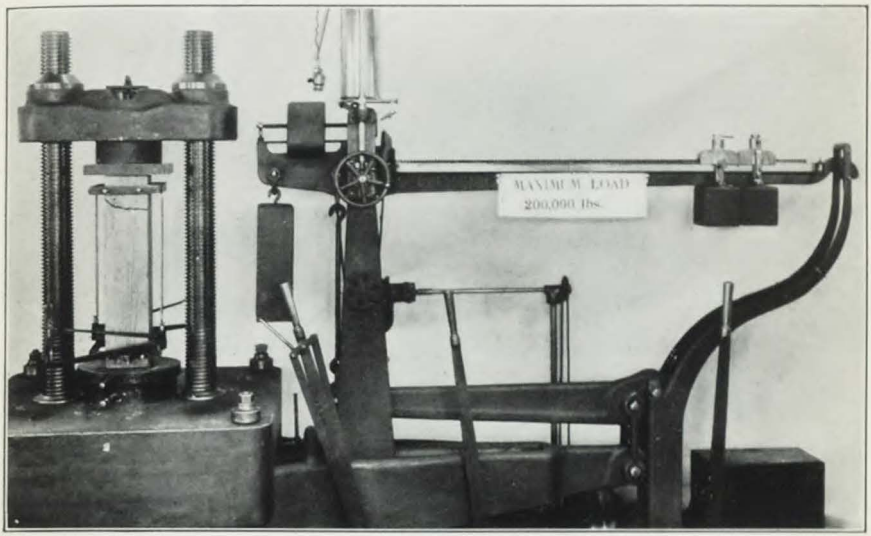


FIG. 2.—METHOD OF TESTING IN COMPRESSION PARALLEL TO GRAIN.

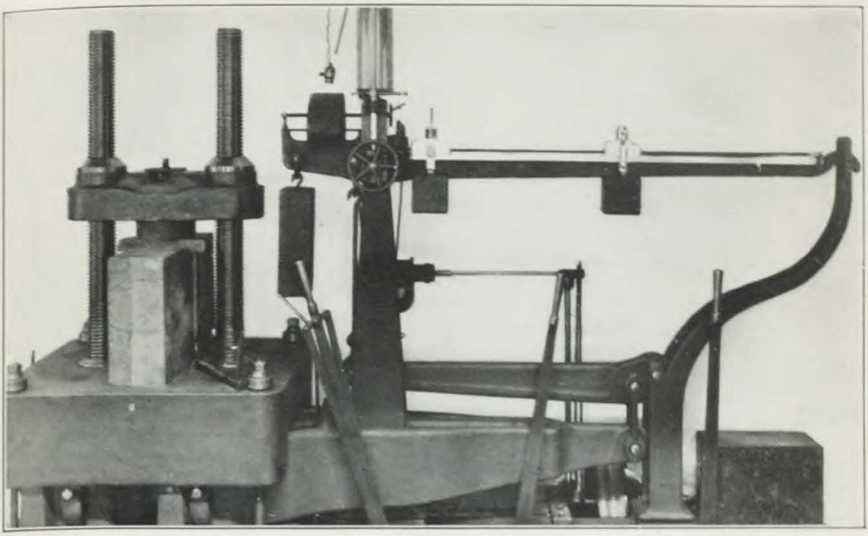


FIG. 1.—METHOD OF TESTING IN COMPRESSION PERPENDICULAR TO GRAIN.

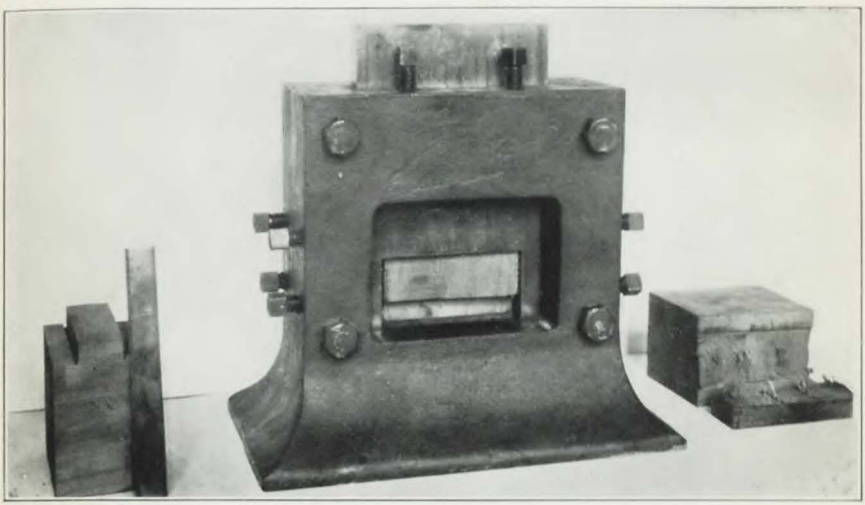


FIG. 2.—METHOD OF MAKING SHEARING TEST.

timber, immediately after test, as near as possible to the center of the length of the beam. These disks were cut up so that the area of the disk was divided into approximately three equal portions. The moisture content of each portion was obtained separately. The crosshatched areas indicate the general method of dividing the

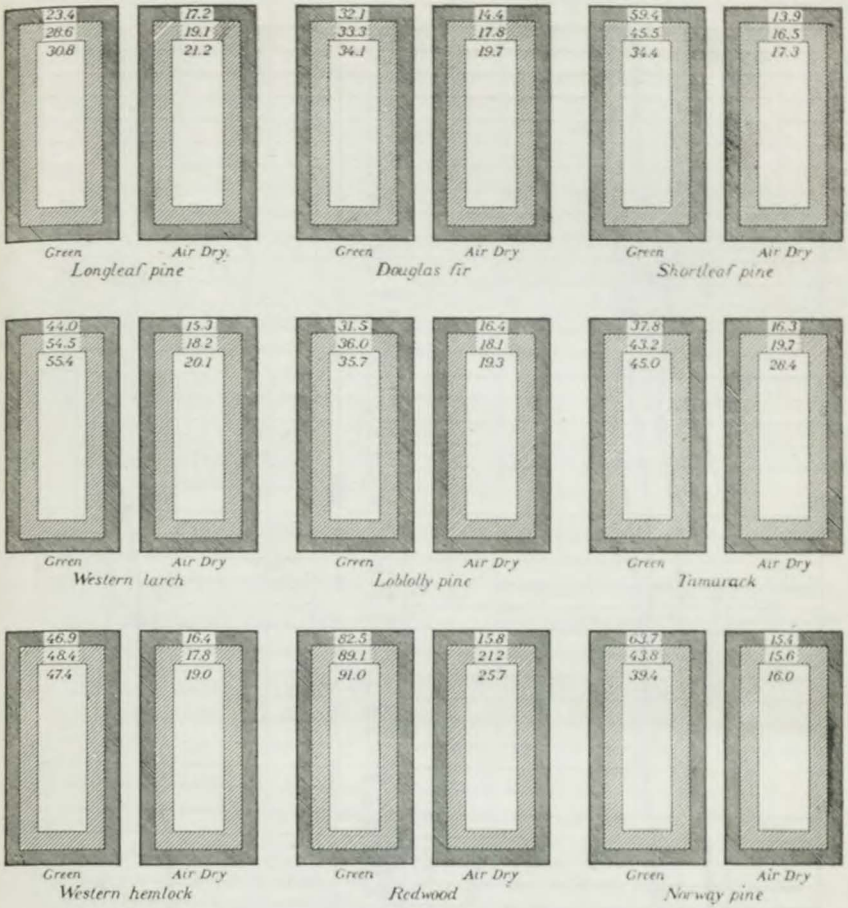


FIG. 2.—Average moisture distribution as determined by sectional disks cut from green and air-seasoned structural sizes.

disks, and the figure within each area gives the average moisture content of the outer, intermediate, or central portions of all the beams tested. On some of the timbers set aside to air dry, observations were made periodically to determine the loss in weight and the amount of shrinkage in cross section. The average results of these

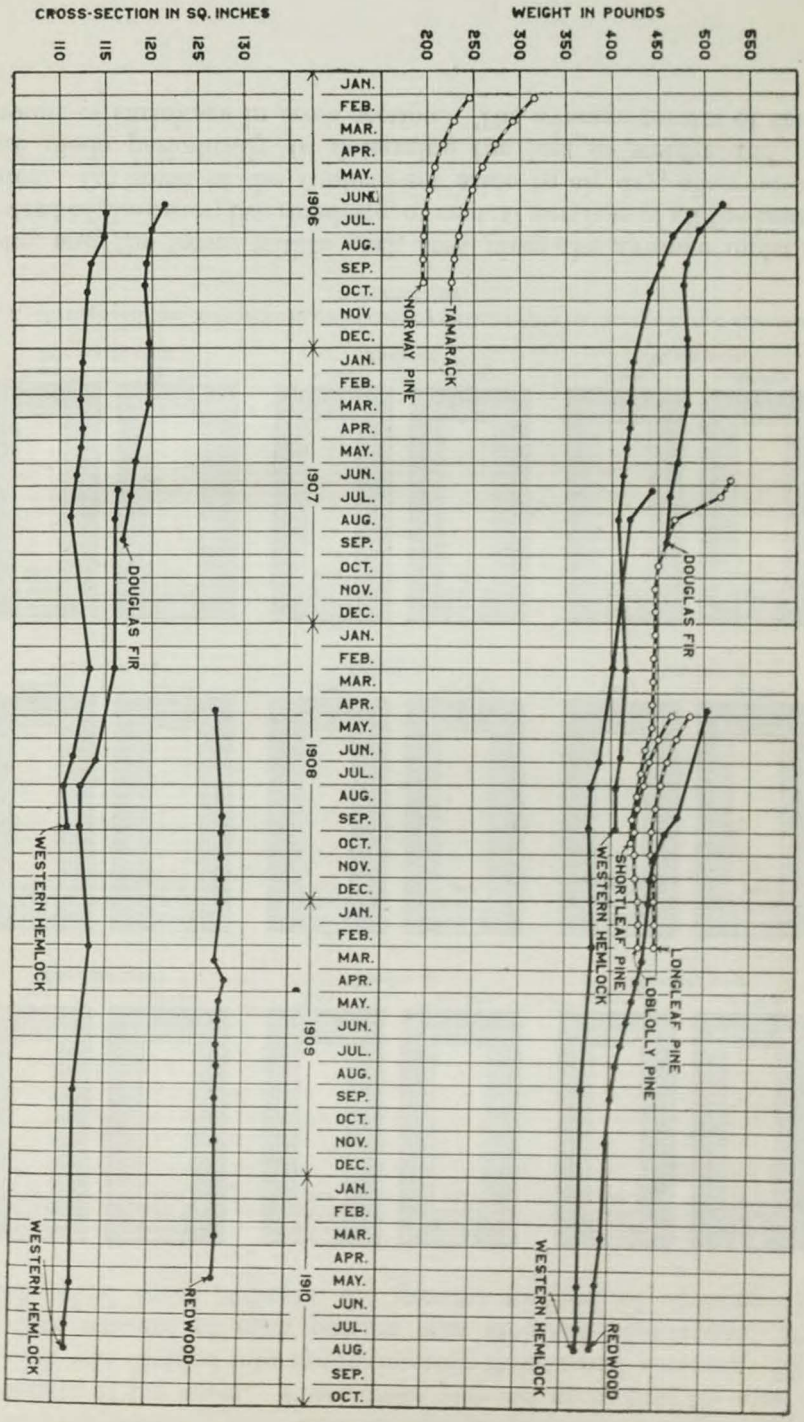


Fig. 3.—Loss in weight and shrinkage in cross section due to seasoning.

records for each species are shown graphically in text figure 3.[1] The following general conclusions are based on text figures 2 and 3:

(1) In general, timber 8 by 16 inches in cross section must season through two entire summers before it reaches a thoroughly air-dry condition.

(2) The weight of thoroughly air-seasoned timbers will vary appreciably during the year, due to the alternate evaporation and absorption of moisture. This change in moisture content is accompanied by a corresponding shrinking and swelling (see drying and shrinkage curves for western hemlock, fig. 3), which tends to increase the size and number of checks formed through the seasoning process. These hygroscopic changes, however, do not seem to affect the interior of the timbers.

(3) If seasoning is started in the hot summer months the loss of moisture is at first very rapid, even though the timber is protected from the sun and wind. Figure 3 shows that the rapid loss in weight is associated with a marked shrinkage in the outer portion of the timber, which invariably induces checking. The loss in weight in a stringer 8 by 16 inches in cross section and 16 feet long in three months varies from 40 to 60 pounds, the loss being proportional in a general way to the amount of sapwood the timber contains. Checking is less serious, however, when the timbers contain a considerable amount of sapwood than when they are practically all heartwood.

(4) The best results are obtained when the air seasoning is started in the late fall or early winter months. At this time of the year the air is usually moist enough to prevent rapid drying on the surface, and, in consequence, serious checking.

(5) The absence of shrinkage in redwood timbers is very noticeable, although redwood contains a large amount of moisture when cut. On account of its low-shrinkage factor it can be seasoned without serious checking.

AVERAGE RESULTS OF TESTS.

Tables 1 and 2 show the average strength values for different species, both green and air seasoned. The averages for the bending tests are the results, respectively, of tests on timbers ranging in cross section from 4 by 10 inches to 8 by 16 inches, over a 15-foot span, and of tests on small clear specimens (cut from large beams) free from defects. The ratio under each species is that of the results from large timbers to those from small clear specimens.[2]

Many engineering handbooks and other publications dealing with timber quote results of tests made only on small, thoroughly seasoned specimens free from defects. Such values may be from one and one-half to two times as high as stresses developed in large timbers and joists. In applying factors of safety to strength values for timbers it is also extremely important to know the moisture condition of the wood when tested. The ratios given in the tables, therefore, are especially significant.

[1] A more detailed discussion of these data as well as other data on the air seasoning of structural timbers will be given in a future publication of the Forest Service on "The Air Seasoning of Structural Timbers," which is now in the course of preparation.

[2] Tables 10 to 13 of the Appendix give the averages of tests made on each different size tested, including structural sizes smaller than 4 by 10 inches in cross section.

TABLE 1.—*Average strength values, green structural timbers with ordinary defects and small specimens of green material without defects.*

Species.	Weight per cubic foot, oven dry.	Rings per inch.	Bending.				Compression parallel to grain.			Compression perpendicular to grain.	Shear.
			Fiber stress at elastic limit per square inch.	Modulus of rupture per square inch.	Modulus of elasticity per square inch.	Horizontal shear per square inch.[1]	Crushing strength at elastic limit per square inch.	Crushing strength at maximum load per square inch.	Modulus of elasticity per square inch.	Crushing strength at elastic limit per square inch.	Shearing strength per square inch.
Longleaf pine:	*Lbs.*		*Lbs.*	*Lbs.*	*1,000 lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*1,000 lbs.*	*Lbs.*	*Lbs.*
Structural sizes	35	13.8	3,734	6,140	1,463	353	3,480	4,800	.....	568	.....
Small specimens	.....	.....	4,950	9,070	1,540	.....	.....	4,400	.....	.....	973
Ratio	.....	.....	75	68	95	.....	.....	109	.....	.....	.....
Douglas fir:											
Structural sizes	28	11.0	3,968	5,983	1,517	166	2,770	3,495	1,414	570	.....
Small specimens	.....	.....	5,227	8,280	1,597	.....	3,500	4,030	1,925	.....	765
Ratio	.....	.....	76	72	95	.....	79	87	74	.....	.....
Shortleaf pine:											
Structural sizes	30	12.1	3,237	5,548	1,473	332	2,460	3,435	1,548	351	.....
Small specimens	.....	.....	4,350	7,710	1,395	.....	.....	3,570	.....	400	704
Ratio	.....	.....	74	72	106	.....	.....	96	.....	88	.....
Western larch:											
Structural sizes	28	24.3	3,324	4,948	1,301	288	2,675	3,510	1,575	456	.....
Small specimens	.....	.....	4,274	7,251	1,310	.....	3,026	3,696	1,545	.....	700
Ratio	.....	.....	78	68	99	.....	88	95	102	.....	.....
Loblolly pine:											
Structural sizes	31	5.9	3,040	5,084	1,387	335	2,050	2,940	548	500	.....
Small specimens	.....	.....	4,100	7,870	1,440	.....	.....	3,240	.....	.....	630
Ratio	.....	.....	74	65	96	.....	.....	91	.....	.....	.....
Tamarack:											
Structural sizes	30	14.0	2,813	4,556	1,220	261	2,400	3,230	1,373	.....	.....
Small specimens	.....	.....	3,875	6,820	1,141	.....	.....	3,190	.....	.....	668
Ratio	.....	.....	73	67	107	.....	.....	101	.....	.....	.....
Western hemlock:											
Structural sizes	27	15.6	3,516	5,296	1,445	288	2,905	3,355	1,617	434	.....
Small specimens	.....	.....	4,406	7,294	1,428	.....	2,938	3,392	1,737	.....	630
Ratio	.....	.....	80	73	101	.....	99	99	93	.....	.....
Redwood:											
Structural sizes	22	18.8	3,760	4,472	1,042	302	3,194	3,882	1,240	434	.....
Small specimens	.....	.....	4,750	6,980	1,061	.....	3,490	3,980	1,222	569	742
Ratio	.....	.....	79	64	98	.....	92	98	101	76	.....
Norway pine:											
Structural sizes	25	13.7	2,492	3,864	1,133	232	2,065	2,555	1,002	.....	.....
Small specimens	.....	.....	2,808	5,173	960	.....	.....	2,504	.....	.....	589
Ratio	.....	.....	89	75	118	.....	.....	102	.....	.....	.....

[1] Only those pieces which failed first by horizontal shear are included in this column.

TABLE 2.—*Average strength values, air-seasoned structural timbers with ordinary defects and small specimens of air-seasoned material without defects.*

Species.	Weight per cubic foot, oven dry.	Rings per inch.	Bending.				Compression parallel to grain.			Compression perpendicular to grain.	Shear.
			Fiber stress at elastic limit per square inch.	Modulus of rupture per square inch.	Modulus of elasticity per square inch.	Horizontal shear per square inch.[1]	Crushing strength at elastic limit per square inch.	Crushing strength at maximum load per square inch.	Modulus of elasticity per square inch.	Crushing strength at elastic limit per square inch.	Shearing strength per square inch.
Longleaf pine:	*Lbs.*		*Lbs.*	*Lbs.*	*1,000 lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*1,000 lbs.*	*Lbs.*	*Lbs.*
Structural sizes	39	15.4	3,691	5,749	1,705	272	3,480	4,800	.....	572	.....
Small specimens	.....	.....	6,750	11,520	1,740	.....	.....	.....	.....	.....	984
Ratio	.....	.....	55	50	98	.....	.....	.....	.....	.....	.....
Douglas fir:											
Structural sizes	28	13.1	4,563	6,372	1,549	221	3,271	4,258	1,038	639	.....
Small specimens	.....	.....	6,686	10,378	1,695	.....	3,842	5,002	1,084	.....	822
Ratio	.....	.....	68	61	91	.....	85	85	96	.....	.....
Shortleaf pine:											
Structural sizes	31	12.4	4,675	6,573	1,726	364	4,070	6,030	1,951	796	.....
Small specimens	.....	.....	7,780	12,120	1,792	.....	.....	6,380	.....	926	1,135
Ratio	.....	.....	60	54	96	.....	.....	95	.....	86	.....
Western larch:											
Structural sizes	29	22.7	3,503	5,856	1,487	340	.....	5,746	.....	597	.....
Small specimens	.....	.....	5,880	10,254	1,564	.....	.....	5,934	.....	.....	905
Ratio	.....	.....	60	57	95	.....	.....	97	.....	.....	.....
Loblolly pine:											
Structural sizes	32	6.3	3,517	6,118	1,487	434	3,011	4,292	1,206	655	.....
Small specimens	.....	.....	5,170	9,400	1,467	.....	.....	5,547	.....	.....	1,115
Ratio	.....	.....	68	65	101	.....	.....	77	.....	.....	.....
Tamarack:											
Structural sizes	31	12.7	3,730	5,498	1,341	299	3,349	4,320	1,351	.....	.....
Small specimens	.....	.....	7,630	13,080	1,620	.....	.....	4,790	.....	697	879
Ratio	.....	.....	49	42	83	.....	.....	90	.....	.....	.....
Western hemlock:											
Structural sizes	28	17.7	4,398	6,420	1,737	307	4,840	5,814	2,140	473	.....
Small specimens	.....	.....	6,333	10,369	1,666	.....	4,560	5,403	1,923	.....	924
Ratio	.....	.....	69	62	104	.....	106	108	111	.....	.....
Redwood:											
Structural sizes	22	20.1	3,442	3,891	890	.....	.....	4,276	.....	525	.....
Small specimens	.....	.....	4,777	7,798	1,146	.....	.....	5,119	.....	564	671
Ratio	.....	.....	72	50	78	.....	.....	84	.....	93	.....
Norway pine:											
Structural sizes	27	10.0	4,069	6,054	1,418	278	3,047	4,228	1,367	.....	.....
Small specimens	.....	.....	5,280	8,470	1,158	.....	.....	7,550	.....	924	1,145
Ratio	.....	.....	77	72	122	.....	.....	56	.....	.....	.....

[1] Only those pieces which failed first by horizontal shear are included in this column.

A comparison of the results of tests on air-seasoned material with those on green material shows that, in general, all of the mechanical properties are increased by seasoning. Increase in strength is especially marked on small pieces free from defects.[1]

Increase in strength of wood fiber due to drying is, in the case of large timbers, largely offset by a weakening of the timber due to the formation of checks. If the moisture content of a seasoned timber is increased it loses strength rapidly, and if thoroughly soaked with

[1] For a complete discussion of the influence of moisture on the strength of wood see Forest Service Bulletin 70, "Effect of Moisture on the Strength and Stiffness of Wood," by H. D. Tiemann.

water will become slightly weaker than when green. On this account it is not safe in practice to depend upon any increase in strength in timbers due to seasoning. When, however, large beams are seasoned with ordinary care, it is safe to assume that they will not at any time be weaker than they were when green. Table 3 gives the ratios of the results secured from seasoned timbers to those secured from green timbers.

It will be seen from Tables 1 and 2 that the shearing stresses developed in small clear specimens are much higher than the calculated shearing stresses developed in beams that failed in horizontal shear. This difference is doubtless due to the fact that, on account of checks and shakes, the actual area resisting shear is likely to be much less than the calculated area used in the formula for horizontal shear. Since large timbers almost invariably form checks during seasoning, it is not safe, in designing timber beams, to use shearing stresses higher than those calculated for beams that failed in horizontal shear.

TABLE 3.—*Ratios of average strength values for air-seasoned material to those for green material.*

Species.	Bending.				Compression parallel to grain.			Compression perpendicular to grain.	Shear.
	Fiber stress at elastic limit per square inch.	Modulus of rupture per square inch.	Modulus of elasticity per square inch.	Horizontal shear per square inch.	Crushing strength at elastic limit per square inch.	Crushing strength at maximum load per square inch.	Modulus of elasticity per square inch.	Crushing strength at elastic limit per square inch.	Shear strength per square inch.
	Pounds.	*Pounds.*	*1,000 lbs.*	*Pounds.*	*Pounds.*	*Pounds.*	*1,000 lbs.*	*Pounds.*	*Pounds.*
Longleaf pine:									
Structural sizes	0.99	0.94	1.16	0.77	1.00	1.00	.....	1.01	.....
Small specimens	1.36	1.27	1.13	.....	.....	.....	.....	.....	1.01
Douglas fir:									
Structural sizes	1.15	1.06	1.02	1.33	1.18	1.22	.73	1.12	.....
Small specimens	1.28	1.25	1.06	.....	1.10	1.24	.56	.....	1.08
Shortleaf pine:									
Structural sizes	1.44	1.19	1.17	1.10	1.66	1.76	1.26	2.26	.....
Small specimens	1.79	1.57	1.28	.....	.....	1.79	.....	2.32	1.61
Western larch:									
Structural sizes	1.05	1.18	1.14	1.18	.....	1.64	.....	1.31	.....
Small specimens	1.38	1.42	1.19	.....	.....	1.60	.....	.....	1.29
Loblolly pine:									
Structural sizes	1.16	1.19	1.07	1.30	1.47	1.46	2.20	1.31	.....
Small specimens	1.26	1.19	1.02	.....	.....	1.71	.....	.....	1.77
Tamarack:									
Structural sizes	1.33	1.21	1.10	1.15	1.40	1.34	.98	.....	.....
Small specimens	2.33	2.26	1.69	.....	.....	1.60	.....	.....	1.32
Western hemlock:									
Structural sizes	1.25	1.21	1.20	1.07	1.67	1.73	1.32	1.09	.....
Small specimens	1.44	1.42	1.17	.....	1.55	1.59	1.11	.....	1.47
Redwood:									
Structural sizes	.92	.87	.85	.....	.....	1.16	.....	1.21	.....
Small specimens	1.00	1.12	1.08	.....	.....	1.29	.....	.99	.90
Norway pine:									
Structural sizes	1.63	1.57	1.25	1.20	1.48	1.66	1.36	.....	.....
Small specimens	1.88	1.64	1.21	.....	.....	3.01	.....	.....	1.94

TABLE 4.—*Calculated shearing stresses developed in structural beams.*

Species.	Total number of tests.		First failure by shear.				Shear following other failure.				No shear failure.			
			Green.		Dry.		Green.		Dry.		Green.		Dry.	
	Green.	Dry.	Per cent of total.	Average calculated shear per square inch.	Per cent of total.	Average calculated shear per square inch.	Per cent of total.	Average calculated shear per square inch.	Per cent of total.	Average calculated shear per square inch.	Per cent of total.	Average calculated shear per square inch.	Per cent of total.	Average calculated shear per square inch.
				Lbs.		*Lbs.*		*Lbs.*		*Lbs.*		*Lbs.*		*Lbs.*
Longleaf pine	17	9	54	353	56	272	23	374	0	.....	23	218	44	286
Douglas fir	191	91	2	166	6	221	22	295	49	294	76	264	45	247
Shortleaf pine	48	13	17	332	46	364	6	327	8	418	77	276	46	340
Western larch	62	52	8	288	27	340	16	314	21	370	76	268	52	287
Loblolly pine	111	25	7	335	28	434	2	356	16	546	91	237	56	255
Tamarack	30	9	10	261	33	299	3	263	0	.....	87	228	67	283
Western hemlock	39	44	5	288	23	307	28	281	68	438	67	250	9	417
Redwood	28	12	7	302	0	.....	11	218	17	250	82	283	83	227
Norway pine	49	10	6	232	10	278	6	266	0	.....	88	209	90	304

Table 4 separates the timbers tested into three groups: (1) Those that failed first in horizontal shear, (2) those that had secondary failures in horizontal shear, and (3) those which did not fail in horizontal shear. The number of specimens falling into each group is given as a percentage of the total number of specimens tested. It will be noticed that of the seasoned timbers from 6 to 56 per cent failed first in shear, and that in Douglas fir, loblolly pine, and western hemlock a considerable proportion had secondary failures in horizontal shear. These figures indicate strongly the need of taking horizontal shear into consideration in the design of timber structures. They also show the necessity of using stresses much lower than those indicated by tests on small clear specimens.

TABLE 5.—*Effect of knots on strength values of Douglas fir, western larch, and western hemlock in compression parallel to grain, large specimens.*

Kind of knot.	Species.	Number of tests.	Rings per inch.	Moisture.	Weight per cubic foot.		Compressive strength at elastic limit per square inch.	Crushing strength at maximum load per square inch.	Modulus of elasticity per square inch.
					At test.	Oven dry.			
No knots.....	Douglas fir:			*Per ct.*	*Pounds.*	*Pounds.*	*Pounds.*	*Pounds.*	*1,000 lbs.*
	Average.....	130	11.8	30.4	38.1	29.2	3,099	3,918	1,321
	High 10 per cent	13	21.7	36.1	43.4	33.4	4,390	4,959	2,707
	Low 10 per cent.	13	5.3	25.7	33.2	25.8	2,070	2,850	623
	Western larch:								
	Average.....	51	25.4	52.3	44.8	29.3	2,635	3,630	1,528
	High 10 per cent	5	37.8	66.8	55.7	34.7	3,782	4,216	1,997
	Low 10 per cent.	5	17.7	39.0	34.9	24.3	1,710	2,956	1,101
	Western hemlock:								
	Average.....	46	15.7	48.5	41.2	27.7	3,018	3,507	1,676
	High 10 per cent	5	26.2	85.2	55.3	32.3	3,593	3,915	2,282
	Low 10 per cent.	5	6.3	30.9	32.8	24.0	2,204	3,045	1,111
Pin knots (sound knots ½ inch or less in diameter).	Douglas fir:								
	Average.....	62	10.4	31.6	37.7	28.6	2,931	3,698	1,401
	High 10 per cent	6	21.0	36.6	43.6	33.1	3,808	4,525	2,681
	Low 10 per cent.	6	4.7	27.4	32.5	24.5	2,017	2,875	642
	Western larch:								
	Average.....	20	21.7	48.1	42.9	28.9	2,955	3,772	1,820
	High 10 per cent	2	28.5	62.9	50.8	32.1	3,625	4,020	2,479
	Low 10 per cent.	2	12.0	35.0	38.3	26.9	1,815	3,445	1,342
	Western hemlock								
	Average.....	12	12.5	48.4	38.1	25.6	2,880	3,396	1,670
	High 10 per cent	1	22.6	61.4	46.2	29.8	3,610	3,630	1,957
	Low 10 per cent.	1	7.7	30.2	33.0	22.8	2,630	3,190	1,418
Standard knots (sound knots, between ½ and 1½ inches in diameter).	Douglas fir:								
	Average.....	227	9.0	30.9	37.8	28.9	2,708	3,386	1,187
	High 10 per cent	23	17.5	39.7	43.8	33.4	3,798	4,538	2,467
	Low 10 per cent.	23	4.4	24.7	32.7	31.0	1,832	2,428	576
	Western larch:								
	Average.....	28	24.2	44.5	39.2	27.0	2,577	3,226	1,521
	High 10 per cent	3	31.7	64.6	51.3	31.3	3,340	3,787	1,975
	Low 10 per cent.	3	14.5	32.8	32.8	24.1	1,643	2,800	1,092
	Western hemlock:								
	Average.....	11	15.7	42.0	36.6	25.8	2,838	3,197	1,624
	High 10 per cent	1	26.9	55.9	44.0	28.9	3,280	3,540	1,860
	Low 10 per cent.	1	8.2	30.4	33.0	23.8	2,350	2,775	1,363
Large knots (sound knots, 1½ inches and over in diameter).	Douglas fir:								
	Average.....	97	9.4	29.9	38.0	29.3	2,406	3,062	940
	High 10 per cent	10	19.0	37.2	44.5	33.8	3,426	4,367	2,119
	Low 10 per cent.	10	3.5	24.7	33.0	25.5	1,669	2,129	472
	Western larch:								
	Average.....	8	23.8	46.2	40.5	27.8	2,569	3,069	1,442
	High 10 per cent	1	32.0	72.0	53.7	31.2	3,270	3,670	2,189
	Low 10 per cent.	1	16.0	33.3	34.2	24.6	1,778	2,380	1,092
	Western hemlock:								
	Average.....	13	14.6	42.0	37.9	26.8	2,590	2,901	1,364
	High 10 per cent	1	26.2	61.6	46.3	29.1	3,150	3,405	1,688
	Low 10 per cent.	1	10.0	29.6	34.4	23.8	1,945	2,300	955
Comparison of results; clears =100.	Douglas fir:								
	Pin knots.....						95	94	106
	Standard knots.						87	86	90
	Large knots....						78	78	71
	Western larch:								
	Pin knots.....						112	104	119
	Standard knots.						98	89	100
	Large knots....						98	85	94
	Western hemlock:								
	Pin knots.....						96	97	100
	Standard knots.						94	91	97
	Large knots....						86	83	81

In Table 7 it will be seen that the modulus of rupture developed in the seasoned beams that failed in horizontal shear was, with but few exceptions, higher than the average modulus of rupture for green

timbers. This being the case, it seems that in beams of the general dimensions used in these tests there is slight chance for failure in horizontal shear when a large factor of safety is applied to the modulus of rupture. Short deep beams, however, should be designed for horizontal shear rather than modulus of rupture.

VARIATION OF INDIVIDUAL RESULTS.

In a material as nonhomogenous as timber an average result is only of general significance. It may not actually represent the value of any individual stick, and it may give an erroneous impression unless information is available on the relation the average bears to the results of the individual tests. Figures 4 to 12, inclusive, show how the individual results for the modulus of rupture, fiber stress at elastic limit, and modulus of elasticity vary from the averages quoted for large beams in Tables 1 and 2. These may be explained as follows:

(1) The area between the adjacent horizontal lines represents graphically the percentage of the total number of tests that fell within the limits indicated on the scale at the left, which gives the strength of the pieces in percentages of the average strength. The percentage of the number of pieces is expressed by the figures within the crosshatched areas. For example, by referring to the modulus of rupture diagrams for longleaf pine and Douglas fir (figs. 4 and 5), it will be seen that, in the case of the longleaf pine beams, 15 per cent of the tests fell between 105 and 110 per cent of the average; and in the case of Douglas fir, 11 per cent.

(2) The figures on the left edge of the diagram sum up the percentages within the crosshatched areas starting from the median line; while those to the right sum up the percentages, starting, respectively, from the maximum and minimum points. For example, again referring to the modulus of rupture diagrams for longleaf pine and Douglas fir, by using the scale to the left it will be seen that 38 per cent of the tests on longleaf pine fell within 100 and 120 per cent of the average, and of Douglas fir 35 per cent. By using the scale to the right of the diagram it is seen that 10 per cent of the longleaf pine and 18 per cent of the Douglas-fir beams were higher than 120 per cent of the average.

(3) If a sufficient number of tests could be made on timbers selected at random from mill-run stock the average of the results secured would approximate the average properties of the timbers, and the diagram showing the variation of the individual results from the average would have a smooth contour and be approximately symmetrical with respect to the median line; the diagrams would be very narrow at the ends and widest at the middle, the contour between the ends and the middle being a smooth double curve. The diagram showing the modulus of rupture in bending for small Douglas-fir beams free from defects, on page 20 of Bulletin 88, is an example of a diagram that has reached an approximate condition of stability. This diagram is based upon 423 tests. The shape of the variability diagrams, therefore, shows the range of the quality of the pieces selected for test and should be useful in reaching conclusions regarding the reliability of the averages quoted. Of the diagrams given in this bulletin, that for Douglas fir (fig. 5) most nearly approaches stability. All of the averages quoted, however, would doubtless be changed to a greater or less degree by further tests. The shape of the diagram above and below the median line will assist the reader in judging the probability of further tests increasing or lowering the average values determined.

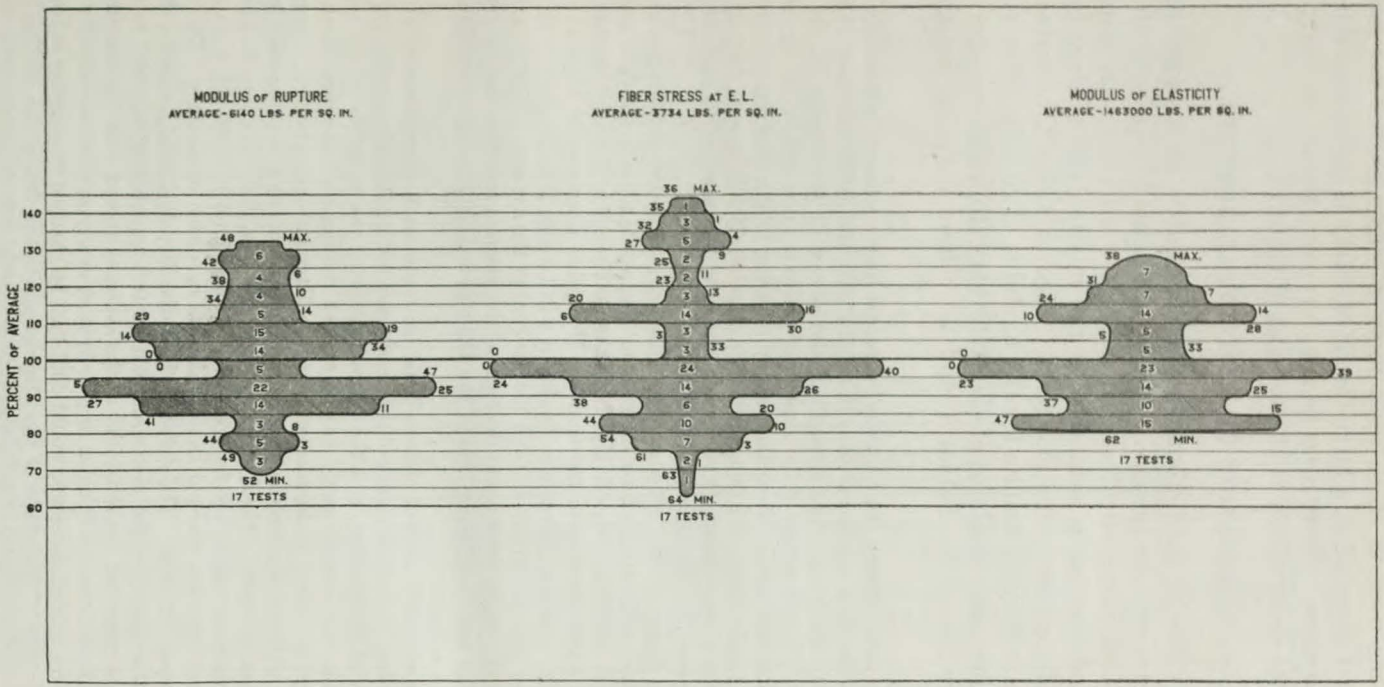


FIG. 4.—Variability of green loblolly pine in modulus of rupture, fiber-stress at elastic limit, and modulus of elasticity.

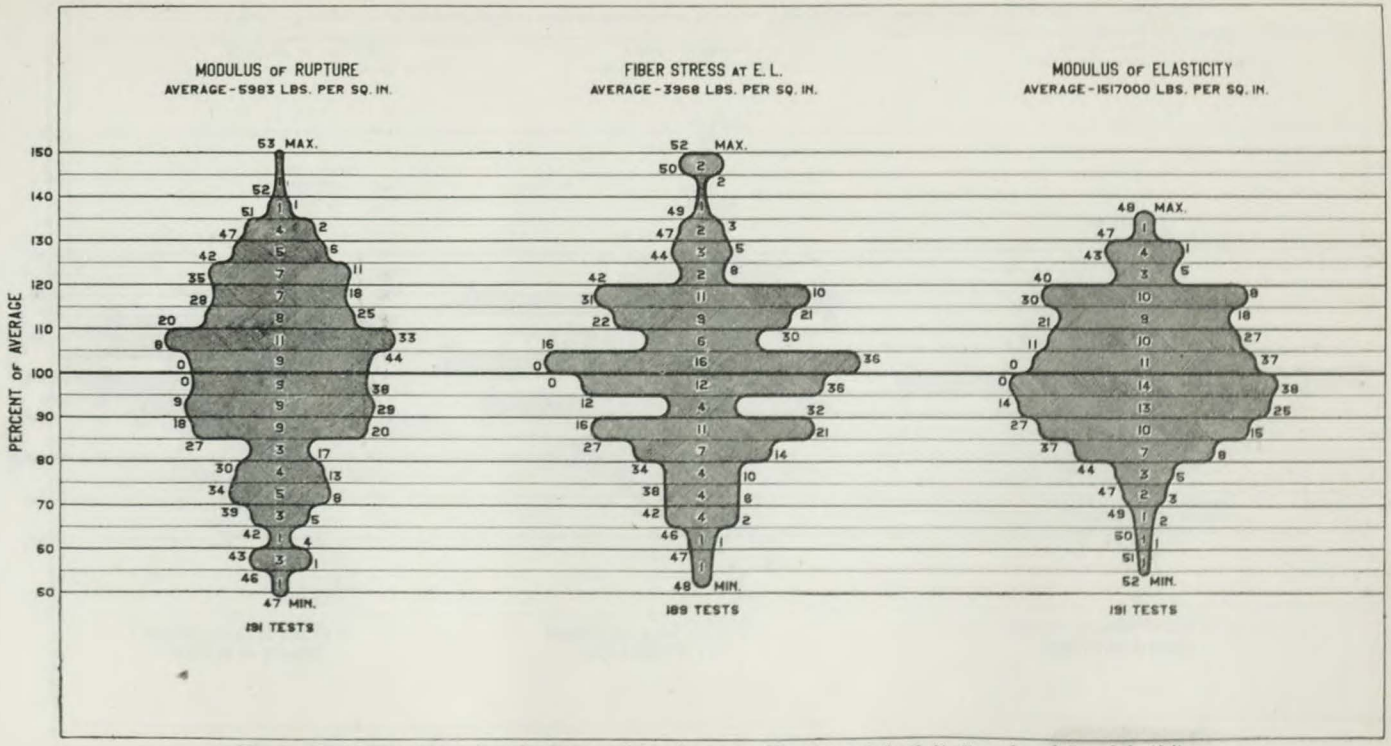


FIG. 5.—Variability of green Douglas fir in modulus of rupture, fiber stress at elastic limit, and modulus of elasticity.

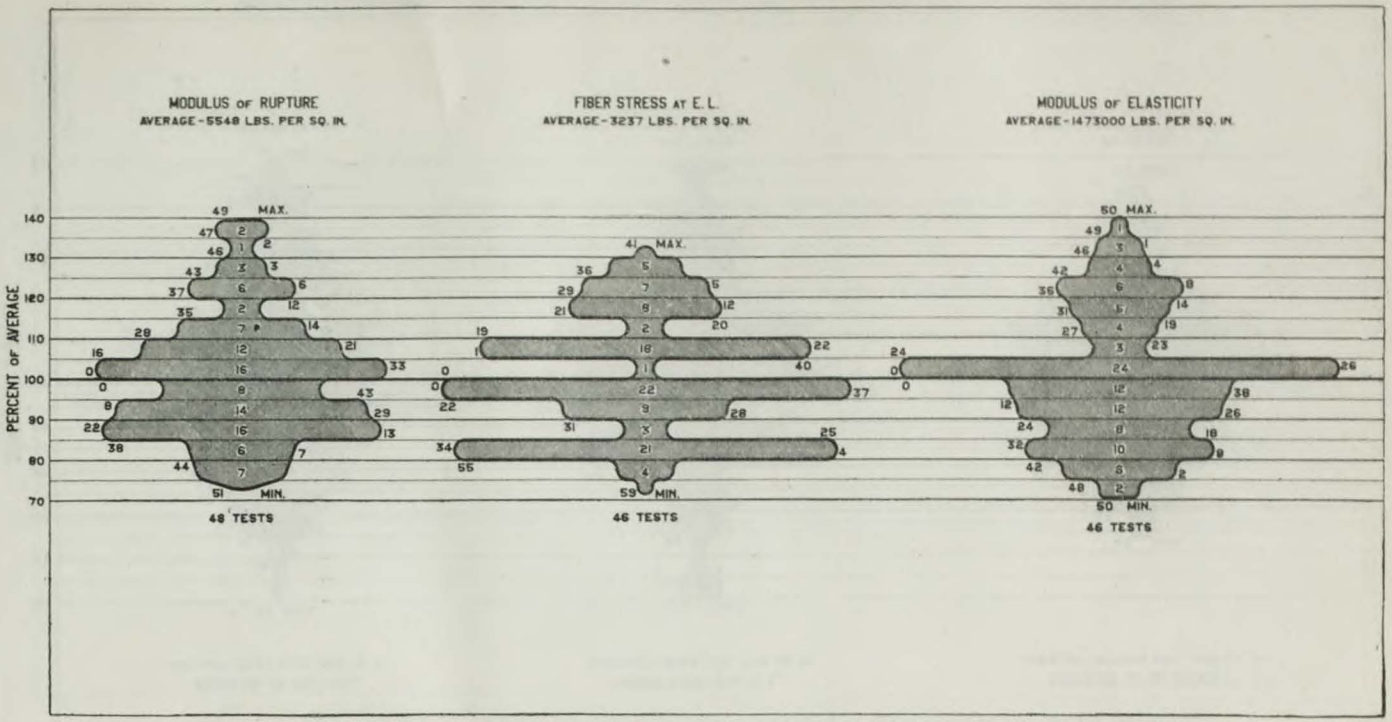


FIG. 6.—Variability of green shortleaf pine in modulus of rupture, fiber stress at elastic limit, and modulus of elasticity.

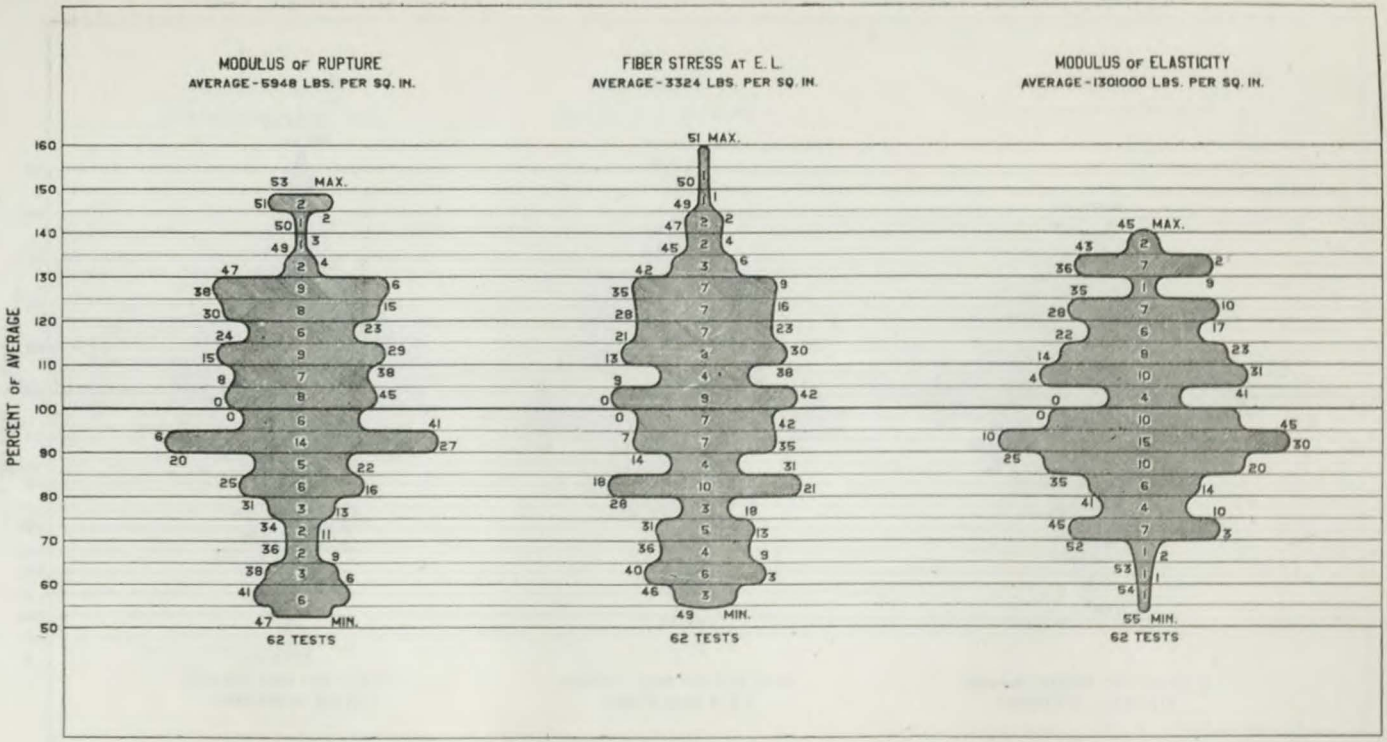


FIG. 7.—Variability of green western larch in modulus of rupture, fiber stress at elastic limit, and modulus of elasticity.

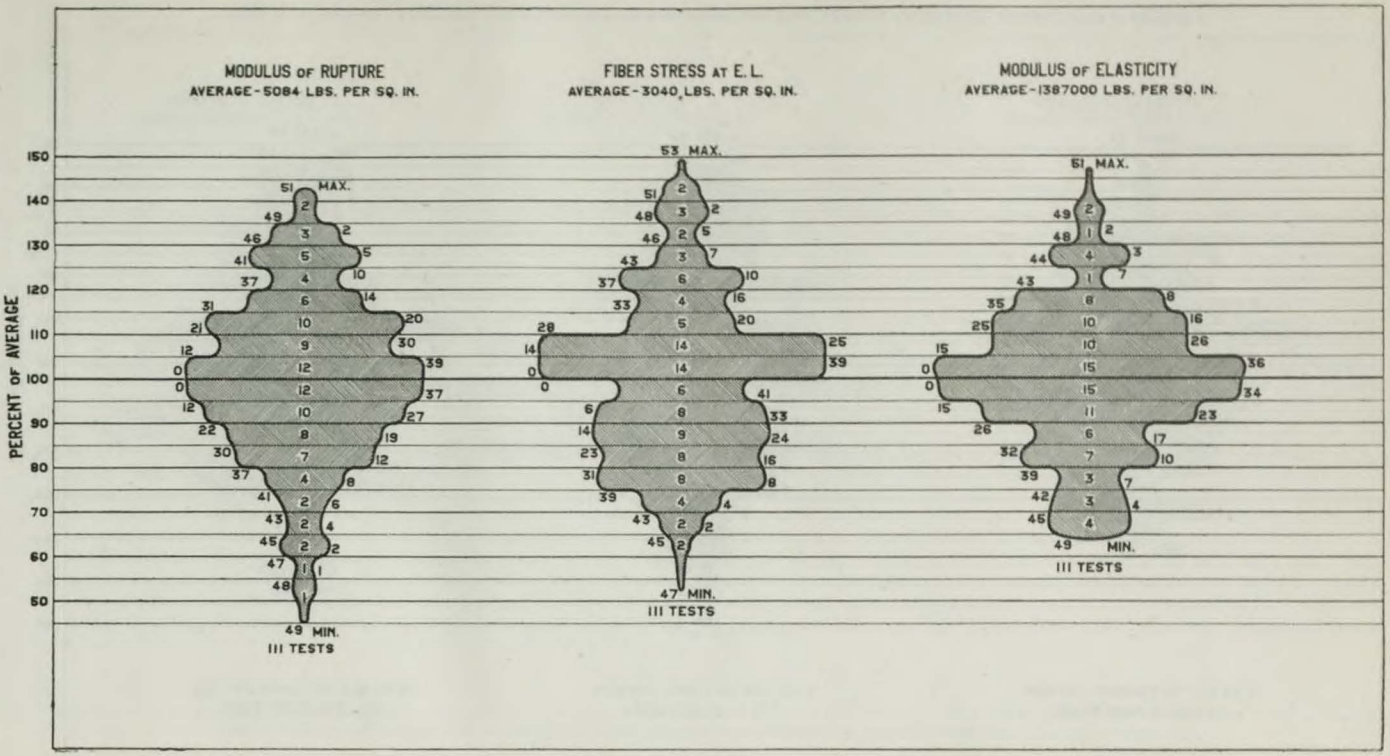


FIG. 8.—Variability of green loblolly pine in modulus of rupture, fiber stress at elastic limit, and modulus of elasticity.

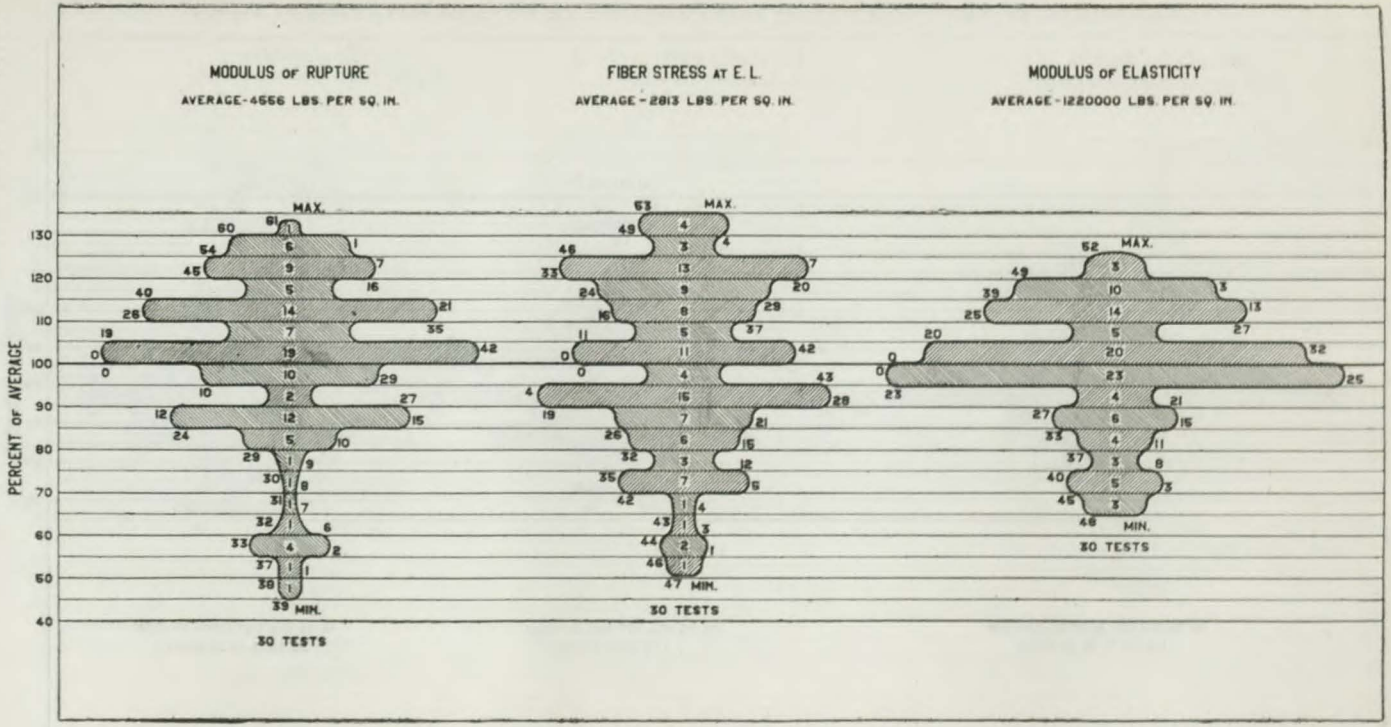


FIG. 9.—Variability of green tamarack in modulus of rupture, fiber stress at elastic limit, and modulus of elasticity.

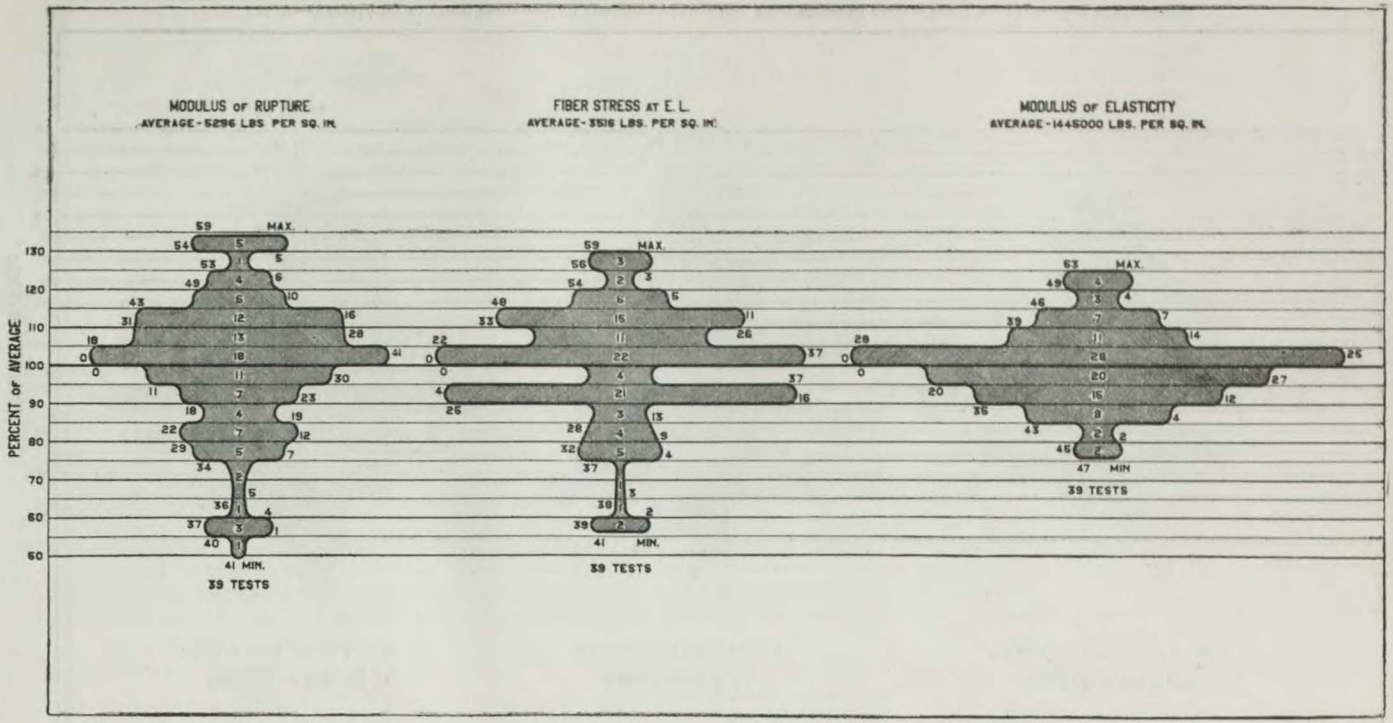


FIG. 10.—Variability of green western hemlock in modulus of rupture, fiber stress at elastic limit, and modulus of elasticity.

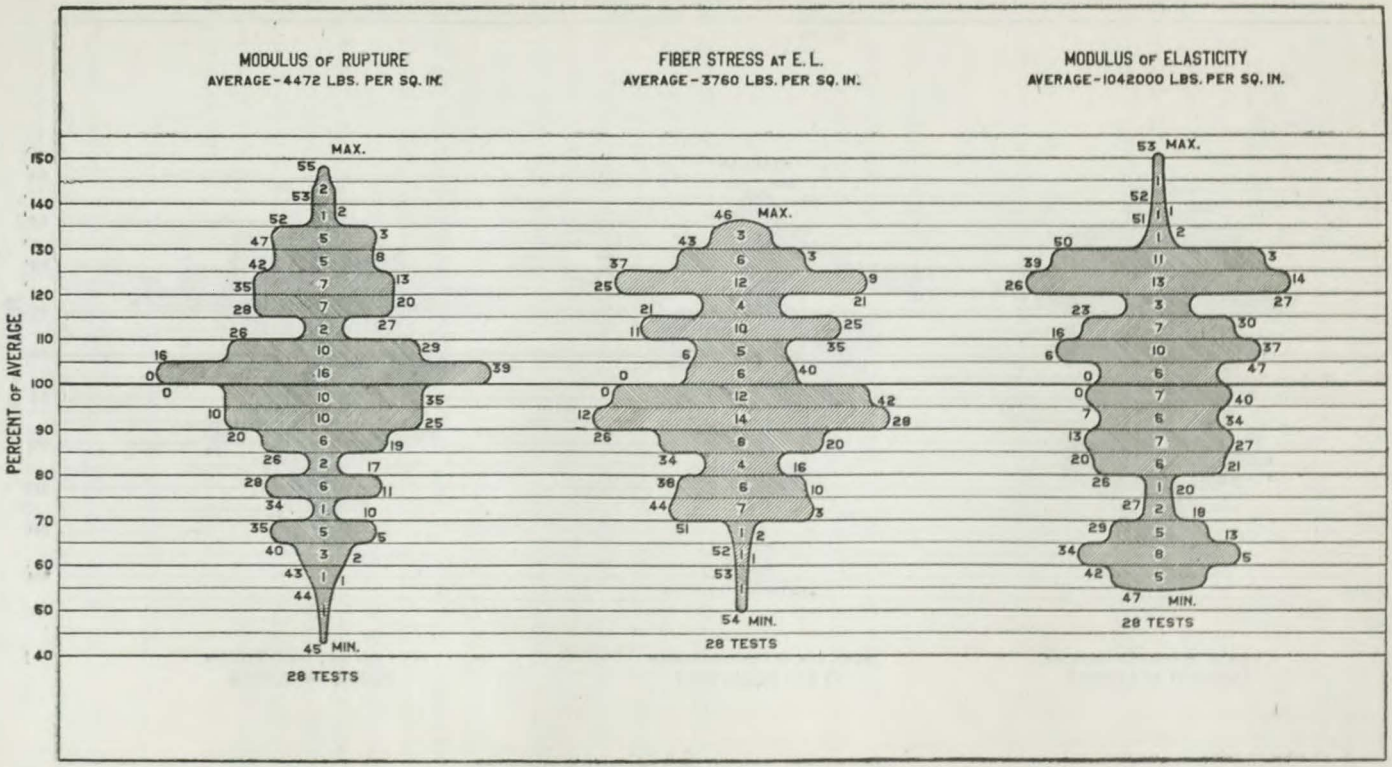


FIG. 11.—Variability of green redwood in modulus of rupture, fiber stress at elastic limit, and modulus of elasticity.

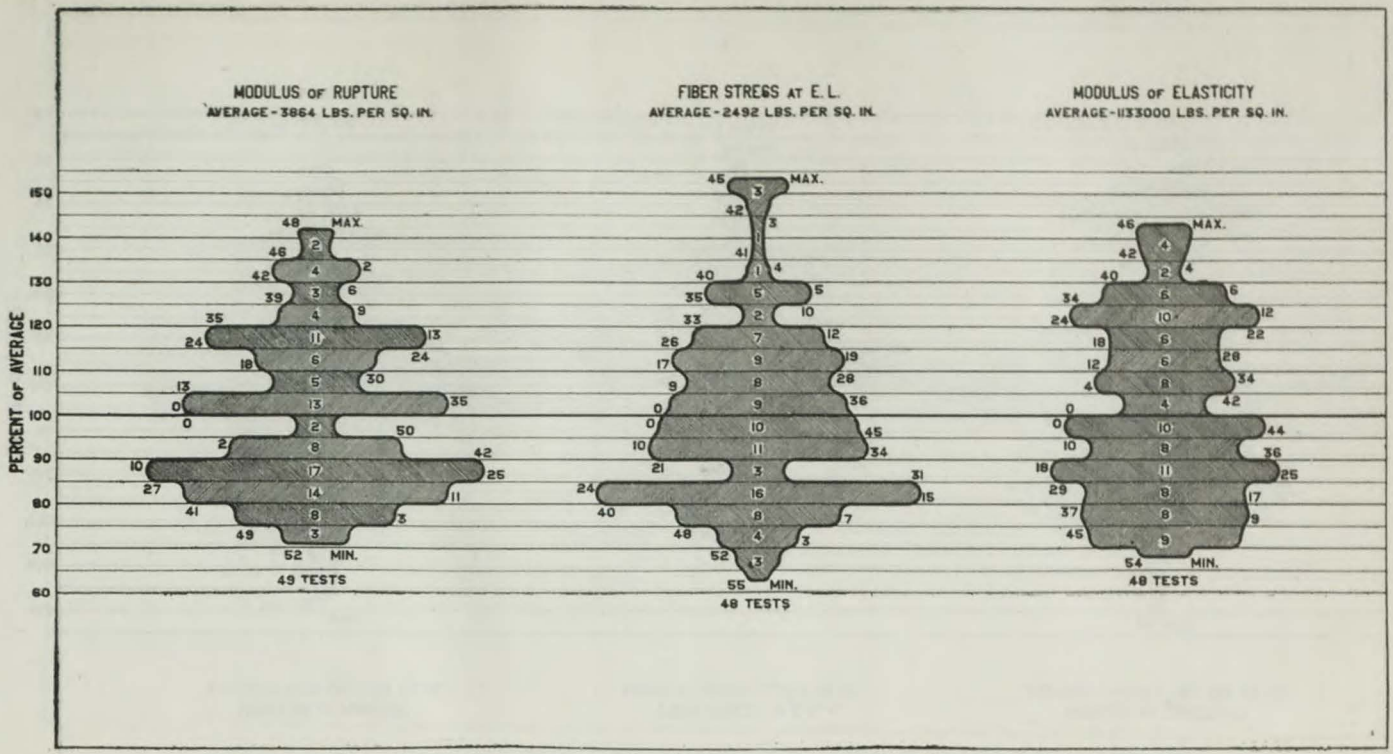


FIG. 12.—Variability of green Norway pine in modulus of rupture, fiber stress at elastic limit, and modulus of elasticity.

RELATION OF MECHANICAL TO PHYSICAL PROPERTIES.

Because the growth of wood is a process of nature and the inherent qualities of the material can not be controlled, the user of structural timber, in framing specifications and grading rules designed to exclude material unsuited to his purposes, must rely entirely upon his knowledge of the general quality of the wood produced by the species under consideration and upon the visible physical characteristics which may be indicative of its quality. The physical characteristics of timber which in most species can be readily determined are:

1. Color of the wood.
2. Relative proportion of heartwood and sapwood.
3. Position of the pith in the cross section.
4. Rate of growth.
5. Weight.
6. Proportion of summerwood.

The purpose of the following analysis is to show which of these physical properties are significant in judging the mechanical properties of timber:

COLOR OF WOOD.

The heartwood of each species of timber has a characteristic color, due to the presence of gums, tannins, and other substances resulting from the processes of growth. The sapwood, however, is generally free from coloring matter, and so relatively white. Coloration from such causes apparently does not affect the mechanical properties of the cellulose composing the cell walls, nor therefore the strength of the timber.[1] Marked variation from the characteristic color, however, often indicates incipient decay, especially when it produces a streaked or spotted effect. Some fungi which produce stain do not injure the timber, because they live on the organic matter contained in the sap and do not attack the cell walls. Many of the blue stains noticeable in sapwood are from this source. If, however, abnormal color is associated with punkiness or softness, noticeable by pricking the wood with a knife blade or other instrument, it is safe to conclude that there is decay. Timbers giving evidence of decay were excluded from these tests.

PROPORTION OF HEARTWOOD AND SAPWOOD.

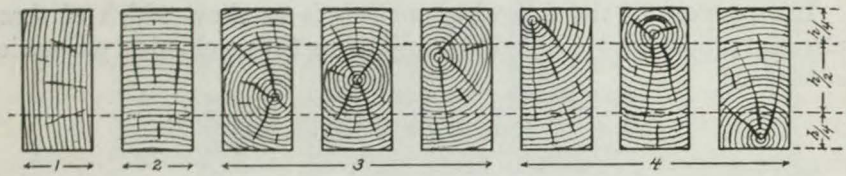
Sapwood, except that from old, overmature trees, is as strong as heartwood, other things being equal, and so far as the mechanical properties of timber go should not be regarded as a defect. From

[1] See Bulletin 88, "Properties and Uses of Douglas Fir," and Circular 142, "Tests on Implement and Vehicle Woods."

the tables of individual tests given in the Appendix it is evident that the per cent of sapwood in the timber does not bear any relation to its breaking strength. Sapwood, however, is invariably less durable than heartwood, and unless the timber is to be treated with some wood preservative it should be excluded as far as possible from structural timbers that are to be used in situations favorable to decay. If, however, the timbers are to be treated, it is not a defect; in fact, because of the relative ease with which it can be impregnated with preservatives it may be made more durable than heartwood. These statements should not be extended, however, to cover joints in frames subjected to wear.

POSITION OF PITH IN CROSS SECTION.

In many specifications for structural timbers reference is made to "boxheart," by which is meant a certain position of the pith or



1- Pith not in cross-section. Rings vertical.
2- " " " " " Rings horizontal.
3- Pith within center half of cross-section
4- " " upper or lower quarters of cross-section.

FIG. 13.—Classification of cross sections of test specimens.

center of the tree with respect to the timber. Figure 13 shows the method of classifying the timbers tested according to the position of the pith in the cross section. The classes into which the timbers fall are indicated, for green material, in column 9 of Table 14, and for air-seasoned material, in column 10 of Table 15. It is seen that the position of the pith does not bear any apparent relation to the strength of the timber. Seasoning checks, however, extend from the surface toward the pith, and when this is near the neutral plane there is a greater tendency for checks to form there and thus decrease the resistance of the beam to horizontal shear. An examination of the results of tests on seasoned timbers of all species tested shows that 22 per cent of the timbers failing first in the horizontal shear fell in class 1, 0 per cent in class 2, 76 per cent in class 3, and 2 per cent in class 4.

RATE OF GROWTH.

The average rate of growth is determined by counting the annual rings intersecting a radial line on the cross section and dividing the number of rings by the length of the line in inches. Figure 14 shows the average relation of rate of growth to the modulus of rupture, fiber stress at elastic limit, and modulus of elasticity of small beams free from defects. These curves seem to indicate that for most species there is a rate of growth which, in general, is associated with the greatest strength. For the different species tested this is:

	Rings per inch.
Douglas fir	24
Shortleaf pine	12
Loblolly pine	6
Western larch	18
Western hemlock	14
Tamarack	20
Norway pine	18
Redwood	30

The individual results upon which figure 14 is based varied widely, however, for each particular rate of growth, and too much importance should not be placed on the relations shown, especially in the case of large timbers. Figures 18 to 26, inclusive, show the individual tests upon which the averages given in Table 1 are based, arranged in order of their modulus of rupture. These diagrams give also the rate of growth for each of the large timbers tested. If rate of growth bore any relation to the breaking strength of large timbers, the line showing the rings per inch should have some general trend other than horizontal. This is the case to a certain extent in figure 19, where the rings per inch tend to decrease as the breaking strength decreases, and in figure 21, where the rings per inch tend to increase as the strength decreases. In all of the other diagrams, however, no such tendency is noticeable. It seems safe to conclude, therefore, that rings per inch are not a reliable index to the mechanical properties of timber, especially structural timbers containing knots and other defects.

DRY WEIGHT PER CUBIC FOOT.

Figure 15 shows the relation between dry weight and the modulus of rupture, fiber stress at elastic limit, and modulus of elasticity, obtained from tests on small clear beams free from defects. While the strength of the specimens having the same dry weight varies considerably, the variation is not as great as in pieces having the same rate of growth. This diagram simply confirms the conclusion which has been repeatedly brought out in the analysis of tests on timber that the mechanical properties of wood vary directly with

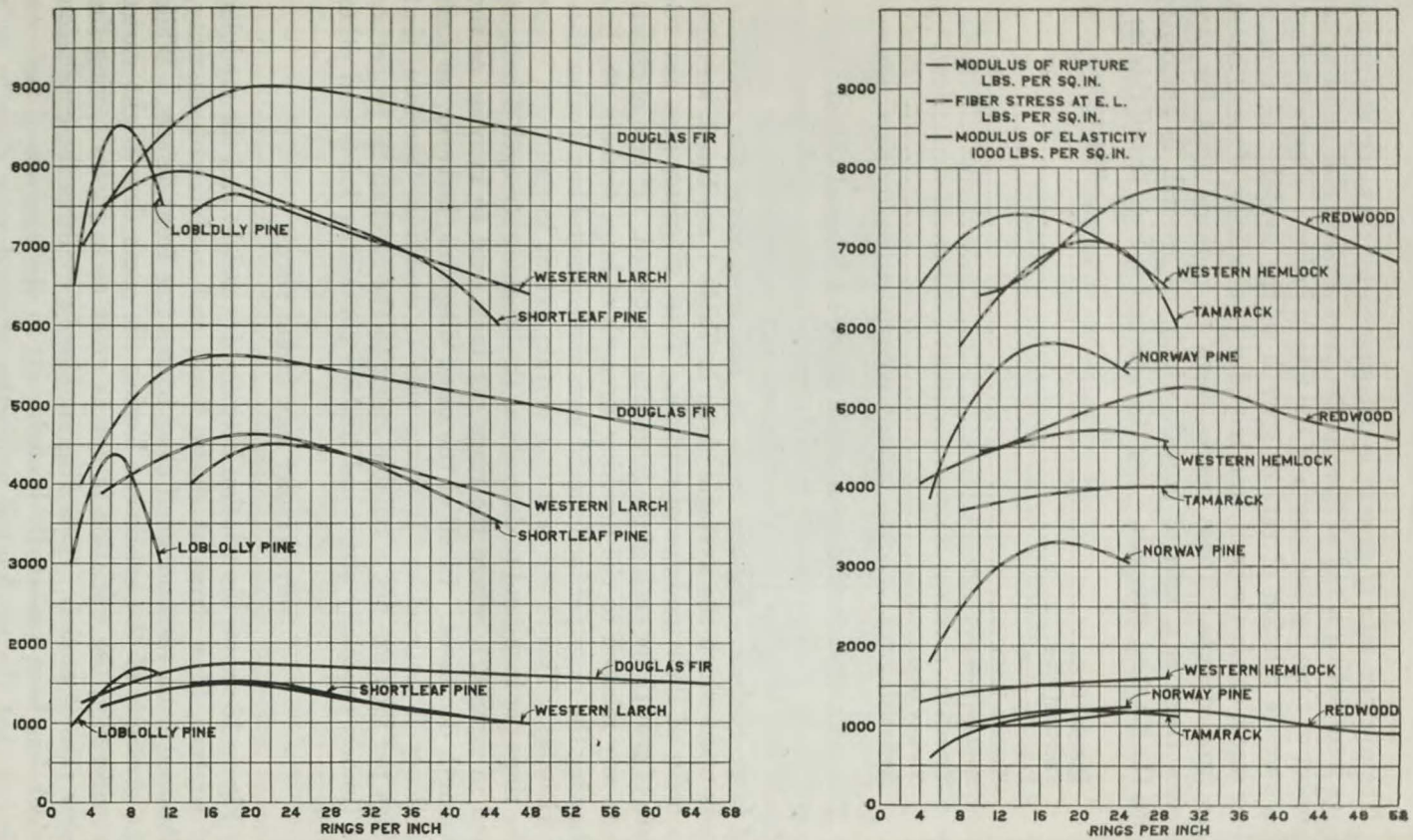


FIG. 14.—Relation of modulus of rupture, fiber stress at elastic limit, and modulus of elasticity to rate of growth, as shown by number of rings per inch.

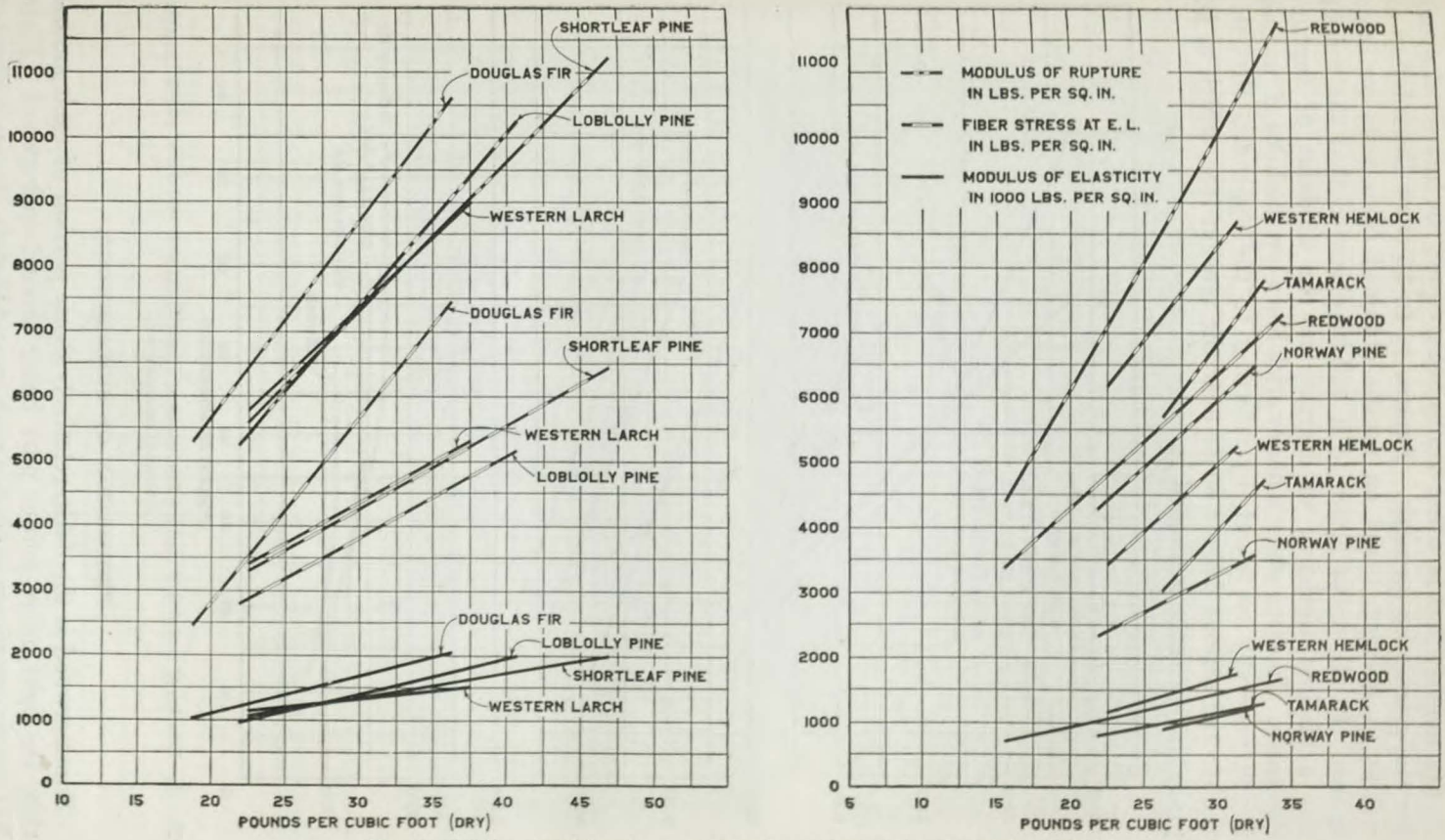


FIG. 15.—Relation of modulus of rupture, fiber stress at elastic limit, and modulus of elasticity.

its dry weight; that is, other things being equal, the heavier the timber the greater its strength. Figures 18 to 26 show the relation of weight to strength based on results obtained from tests on large beams. In all except figure 18 it will be observed that the weight has a distinct tendency to decrease as the modulus of rupture decreases. In cases where a heavy stick has a low modulus of rupture it will generally be found, by referring to the appendix, that the timber had serious defects on or near the tension face, which in all probability greatly weakened it.

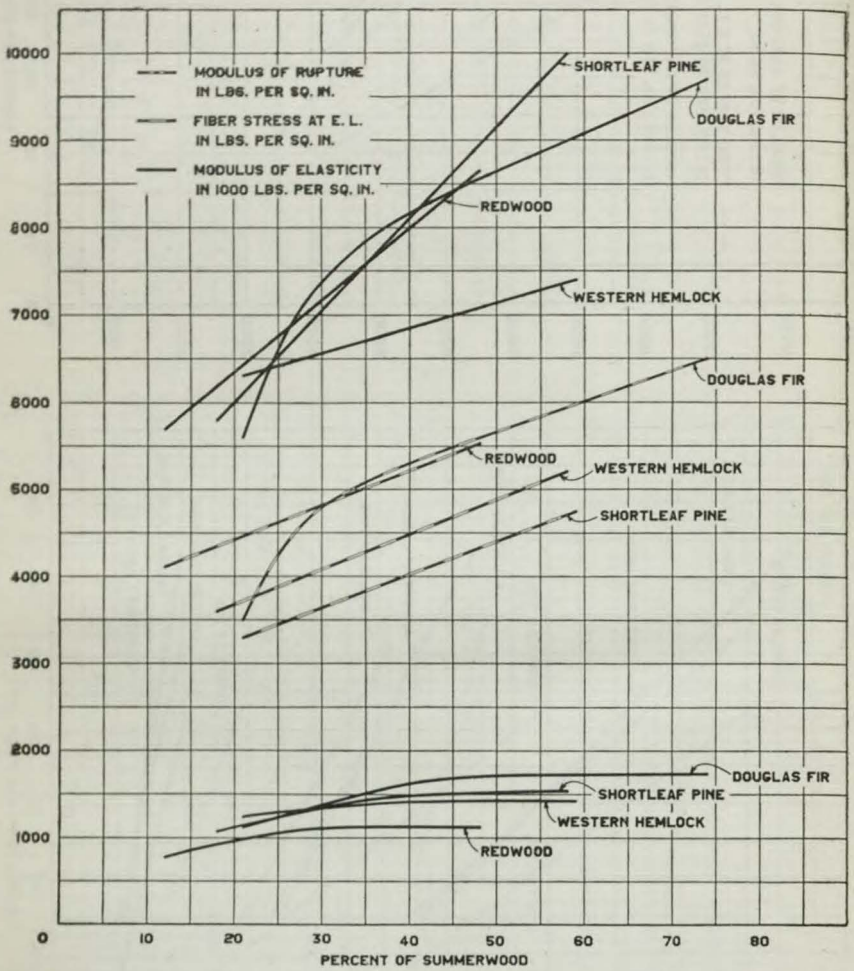
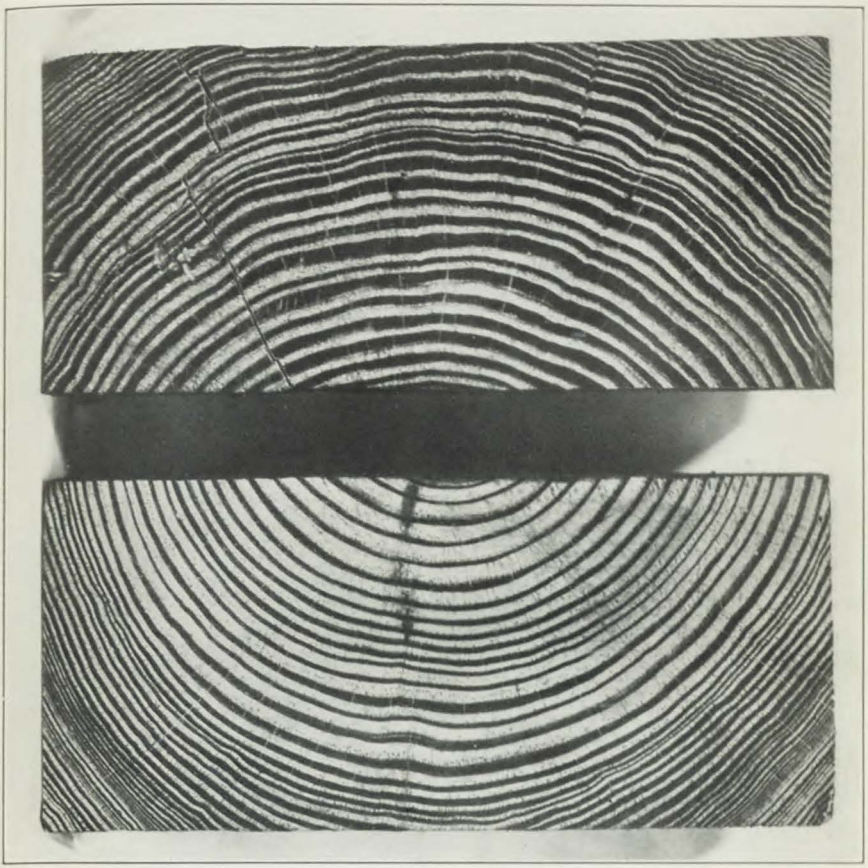


FIG. 16.—Relation of modulus of rupture, fiber stress at elastic limit, and modulus of elasticity to percentage of summerwood.

PROPORTION OF SUMMERWOOD.

Summerwood is the dark, relatively dense portion of each annual ring, the light, more porous part being termed springwood. Plate VII shows two pieces of timber with approximately the same number



CROSS SECTION OF TWO LOBLOLLY PINE BEAMS WITH APPROXIMATELY EQUAL RATES OF GROWTH, BUT DIFFERENT PROPORTIONS OF SUMMERWOOD.

(Although both pieces represent approximately the same number of years' growth, the bottom piece is made up of one-third summerwood and two-thirds springwood, while the top one has more than three-fifths summerwood and less than two-fifths springwood.)

of annual rings per inch, but differing greatly in the amount of summerwood they contain. In Forest Service tests summerwood is expressed as a percentage of the area of the cross section. When one-half of the cross section is summerwood the specimen is said to contain 50 per cent of summerwood; when one-fourth, 25 per cent. Figure 17 shows the relation of summerwood to dry weight in some of the timbers studied. The proportion of summerwood was not determined for all of the timbers discussed in this bulletin.

Since the dry weight of timber can not be determined without first ascertaining how much water the piece contains, the relation of

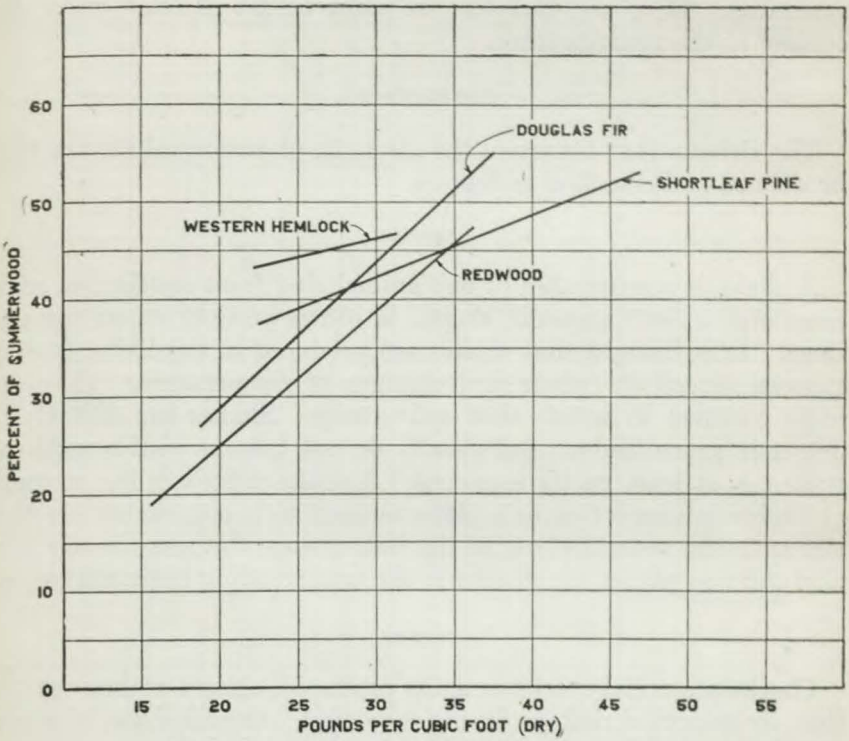


FIG. 17.—Relation of proportion of summerwood to dry weight.

summerwood to dry weight affords a visual method of judging the relative dry weight of timbers in a green condition and permits indirectly the use of weight in grading wood according to its mechanical properties. Figure 16 shows, for small beams free from defects, that the mechanical properties vary with the proportion of summerwood in about the same degree as they do with the dry weight of the material. Yet the proportion of summerwood varies so much in the cross section of a large timber, and defects, such as knots and irregular grain, influence the mechanical properties to a so much greater extent than does the former that it is difficult to bring out

any definite relation between the proportion of summerwood and the strength of large timbers. It is unquestionably true, however, that the proportion of summerwood is an important guide in judging the quality of timber, independent of any defects which it may contain.

DEFECTS.

Defects differ from the physical characteristics just discussed in that they are not always inherent in the timber, but depend to a large degree upon the part of the tree from which the timber is cut, upon the manner of sawing it from the log, and upon the method of seasoning. They are, therefore, to some extent at least, under the control of the manufacturer.

DEFINITIONS.

The defects that influence the strength of structural timber may be defined and classified as follows:

SHAKES.

A shake is a separation of one annual ring from another, in some cases only a few degrees in length, in others entirely separating two rings. It is thought that shakes are produced in the living tree by stresses caused by winds and changes of temperature. They are most common in woods that split easily. Shakes are difficult to detect in green timber, and usually do not become visible until the timber is at least partly seasoned. A shake decreases the strength of timber in proportion as a plane tangent to it approaches parallelism with the neutral plane in the beam, since the more nearly parallel the two planes the smaller is the area resisting horizontal shear.

CHECKS.

Checks are radial cracks or splits produced, almost without exception, by uneven shrinkage during seasoning. Occasionally, however, they are present in green timber.

CROSS GRAINS.

Cross grain may be divided into three general classes:

Diagonal grain.—In sawing lumber, if the plane of the saw is not approximately parallel to the axis of the log the grain of the lumber cut is not parallel to the edges, and is termed diagonal.

Spiral grain.—In many trees the fibers composing each year's growth are ranged spirally instead of vertically. The greater the pitch of the spiral the greater is the defect. Spiral grain usually can not be detected from a casual inspection of the piece, since it does

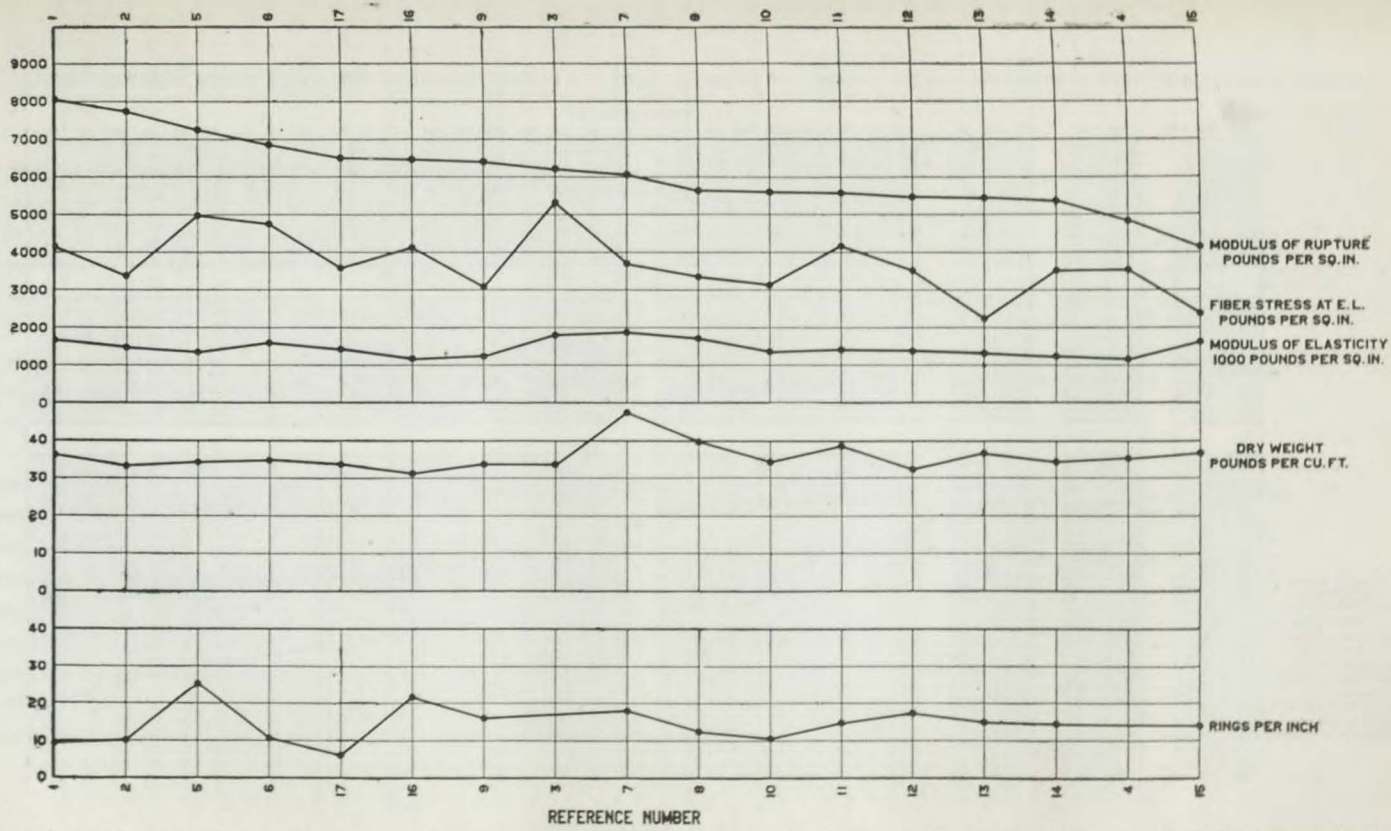


FIG. 18.—Modulus of rupture, fiber stress at elastic limit, modulus of elasticity, dry weight per cubic foot, and rings per inch for structural sizes of green longleaf pine.

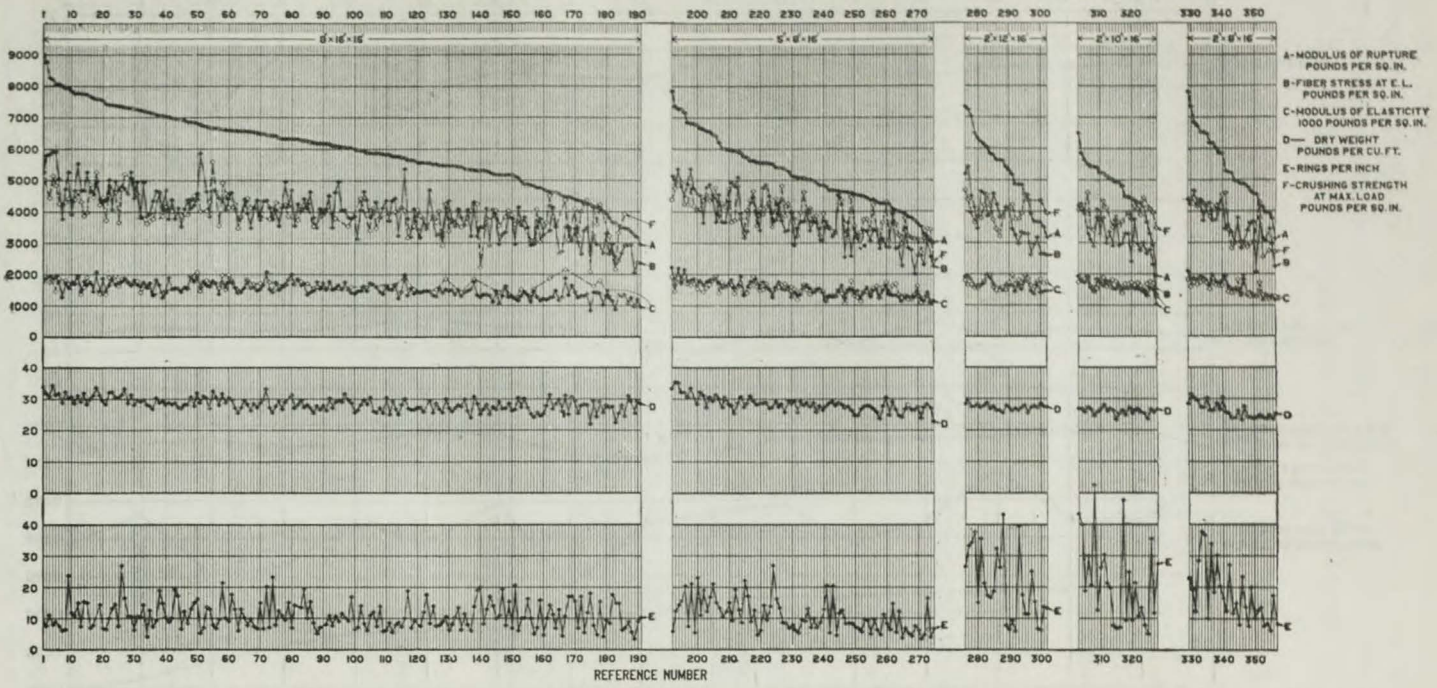

A-MODULUS OF RUPTURE POUNDS PER SQ. IN.
B-FIBER STRESS AT E. L. POUNDS PER SQ. IN.
C-MODULUS OF ELASTICITY 1000 POUNDS PER SQ. IN.
D— DRY WEIGHT POUNDS PER CU. FT.
E-RINGS PER INCH
F-CRUSHING STRENGTH AT MAX. LOAD POUNDS PER SQ. IN.
REFERENCE NUMBER

FIG. 19.—Modulus of rupture, fiber stress at elastic limit, modulus of elasticity, dry weight per cubic foot, and rings per inch for structural sizes of green Douglas fir.

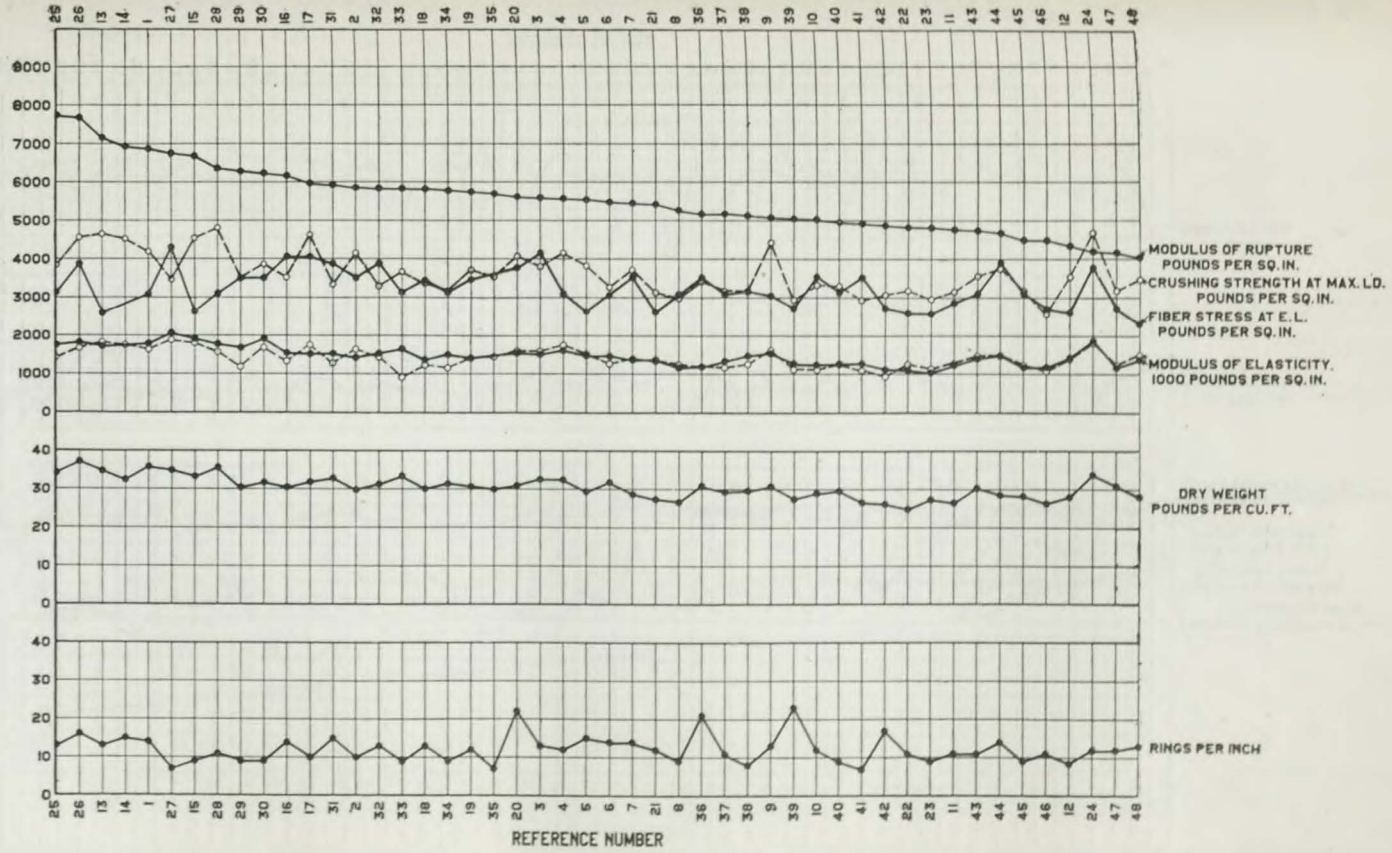


FIG. 20.—Modulus of rupture, fiber stress at elastic limit, modulus of elasticity, dry weight per cubic foot, and rings per inch for structural sizes of green shortleaf pine.

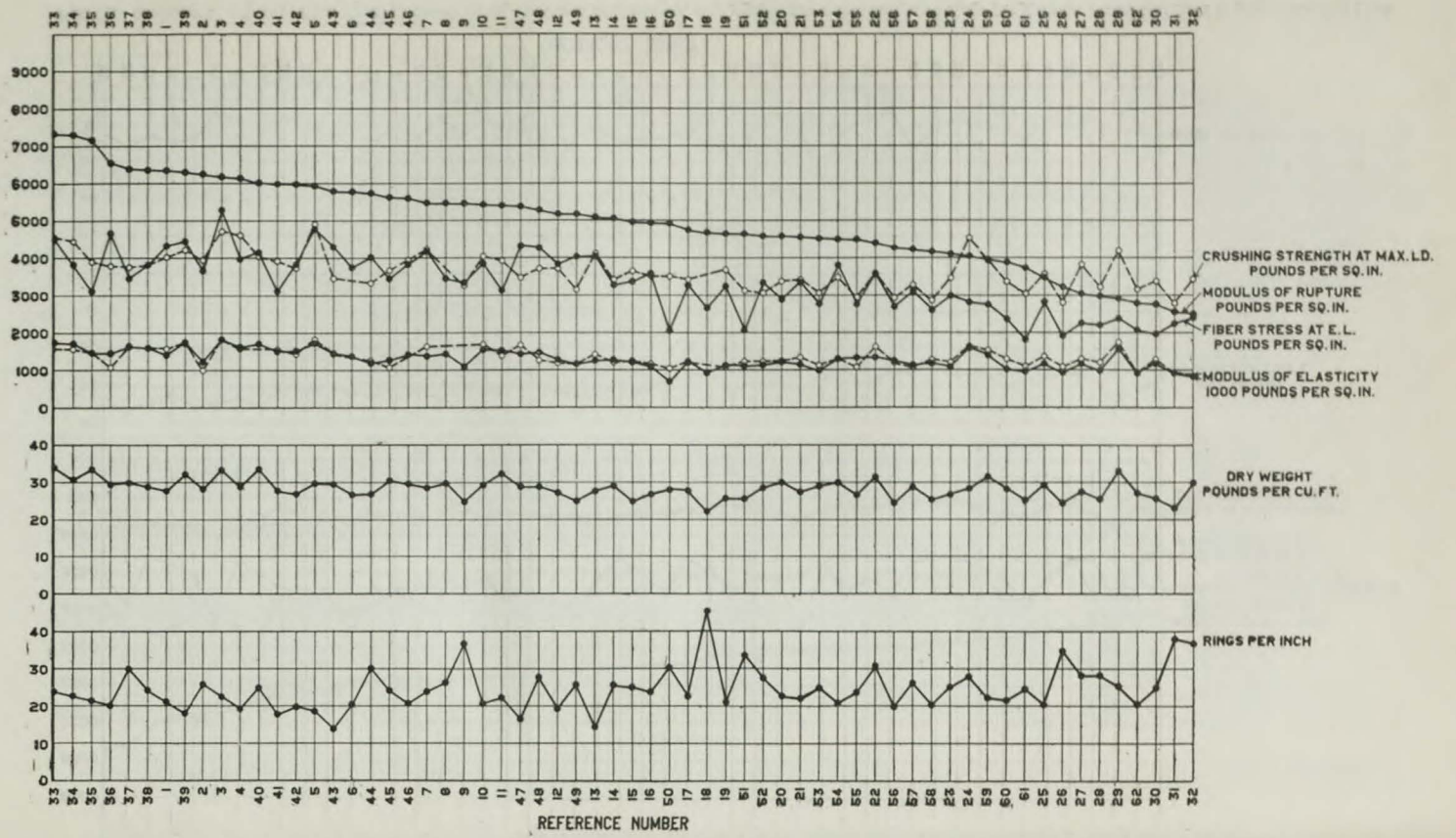


FIG. 21.—Modulus of rupture, fiber stress at elastic limit, modulus of elasticity, dry weight per cubic foot, and rings per inch for structural sizes of green western larch.

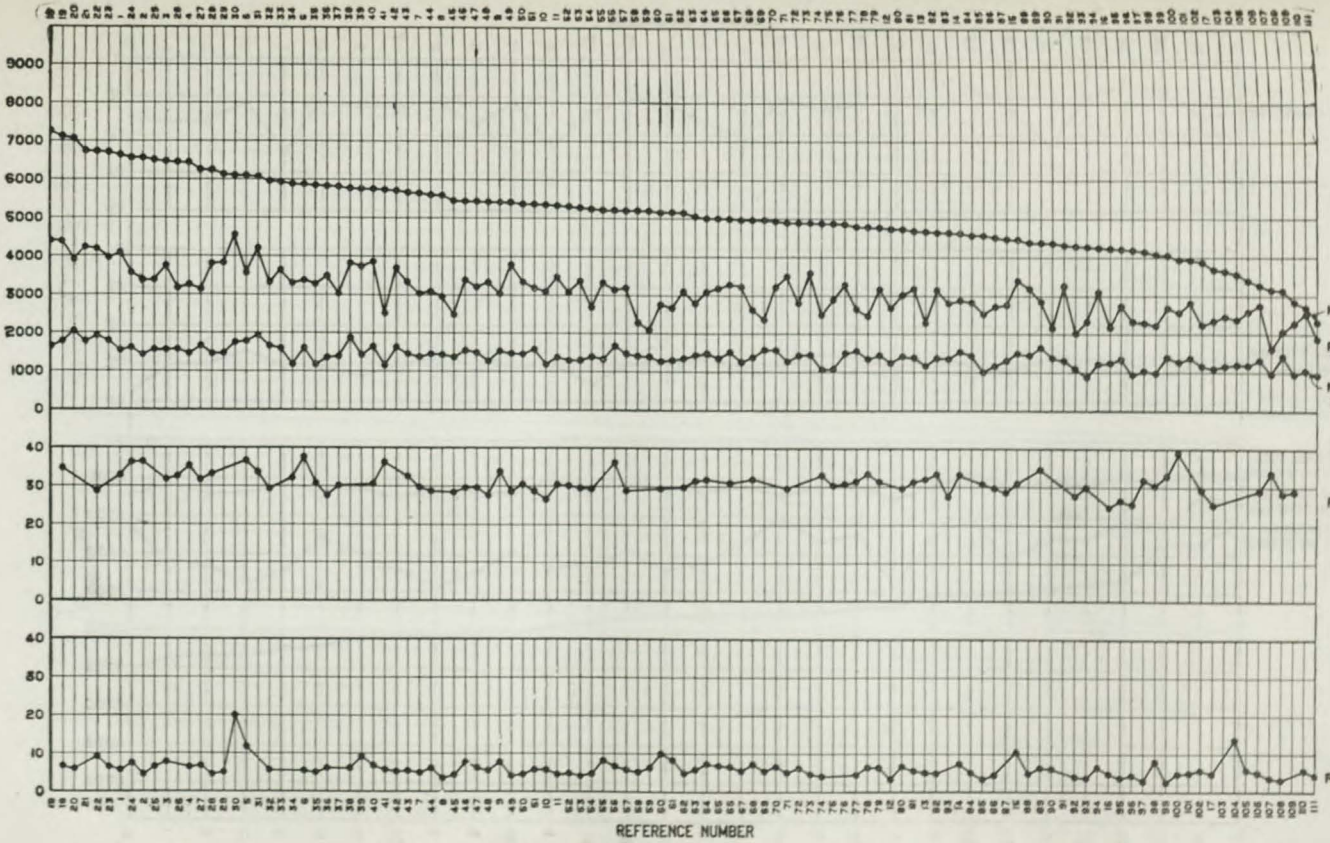


FIG. 22.—Modulus of rupture, fiber stress at elastic limit, modulus of elasticity, dry weight per cubic foot, and rings per inch for structural sizes of green loblolly pine.

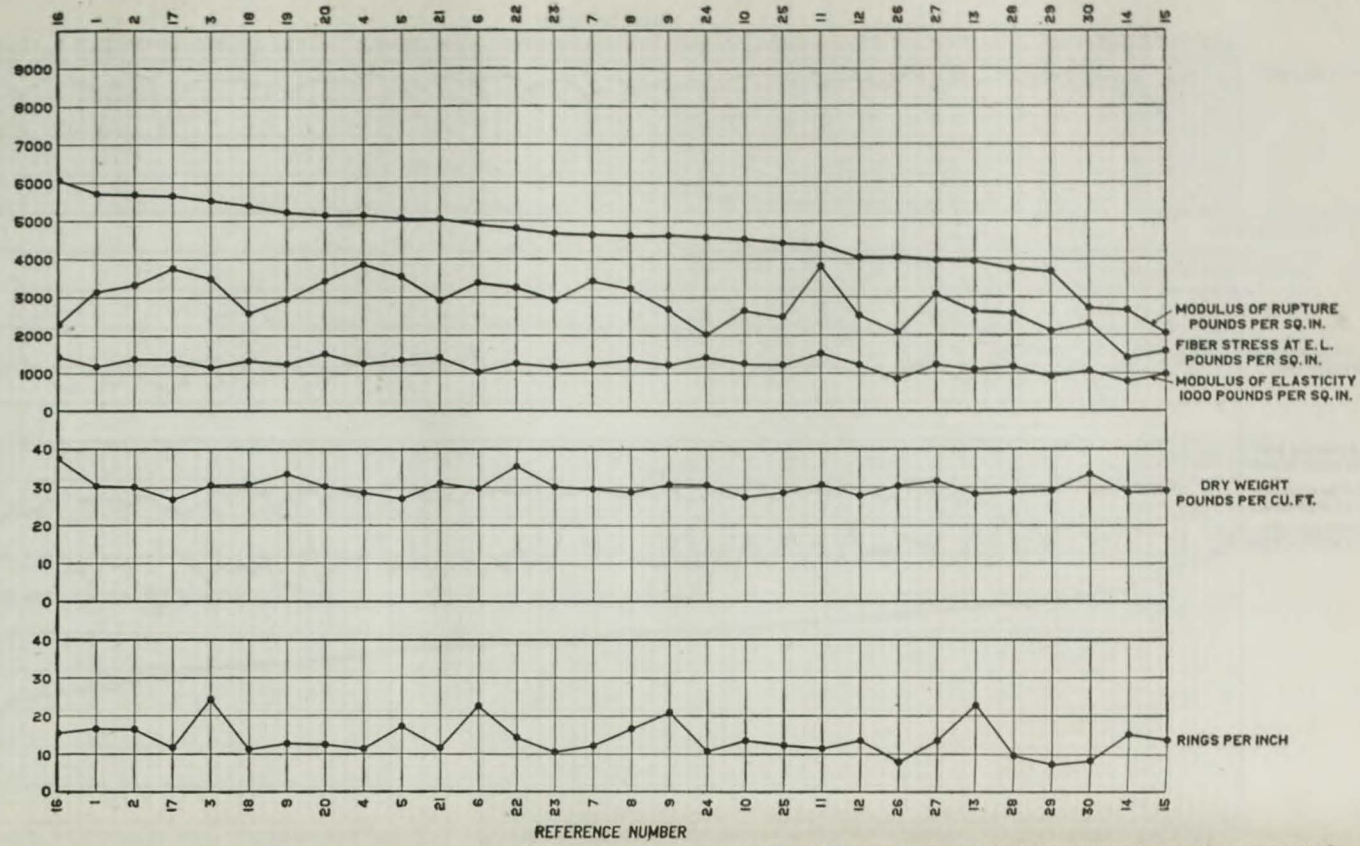


FIG. 23.—Modulus of rupture, fiber stress at elastic limit, modulus of elasticity, dry weight per cubic foot, and rings per inch for structural sizes of green tamarack.

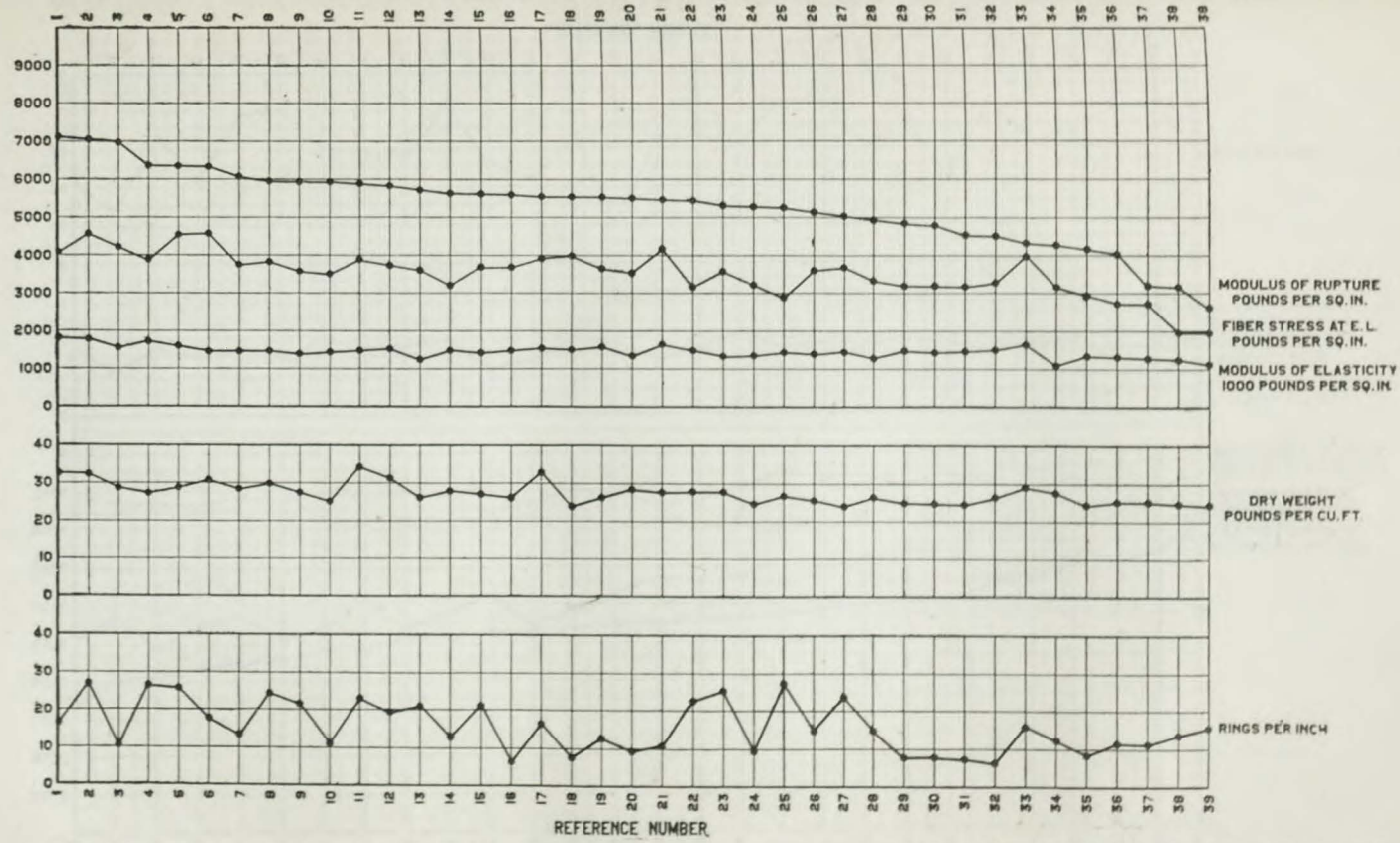


FIG. 24.—Modulus of rupture, fiber stress at elastic limit, modulus of elasticity, dry weight per cubic foot, and rings per inch for structural sizes of green western hemlock.

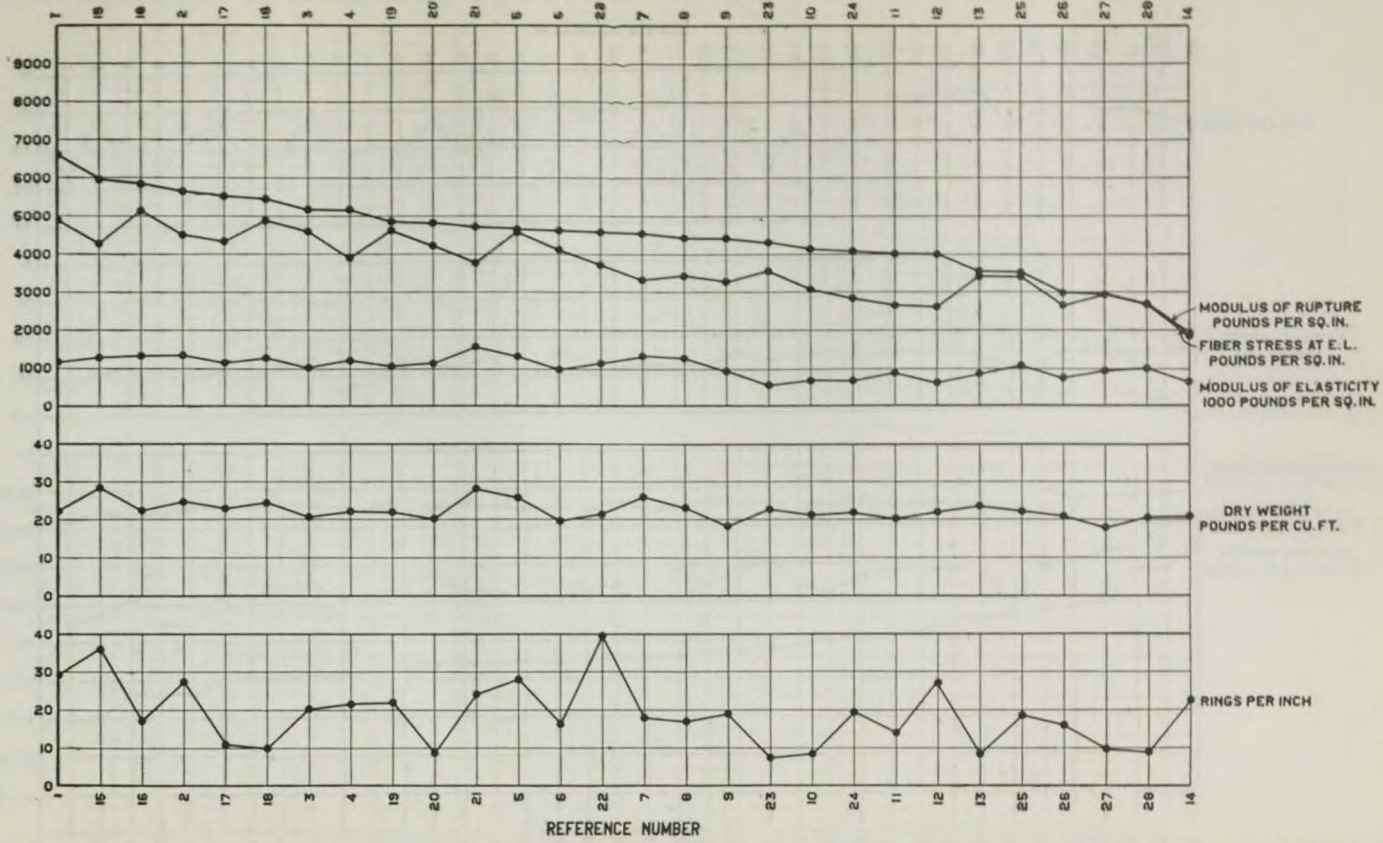

MODULUS OF RUPTURE POUNDS PER SQ. IN.
FIBER STRESS AT E. L. POUNDS PER SQ. IN.
MODULUS OF ELASTICITY 1000 POUNDS PER SQ. IN.
DRY WEIGHT POUNDS PER CU. FT.
RINGS PER INCH
REFERENCE NUMBER

FIG. 25.—Modulus of rupture, fiber stress at elastic limit, modulus of elasticity, dry weight per cubic foot, and rings per inch for structural sizes of green redwood.

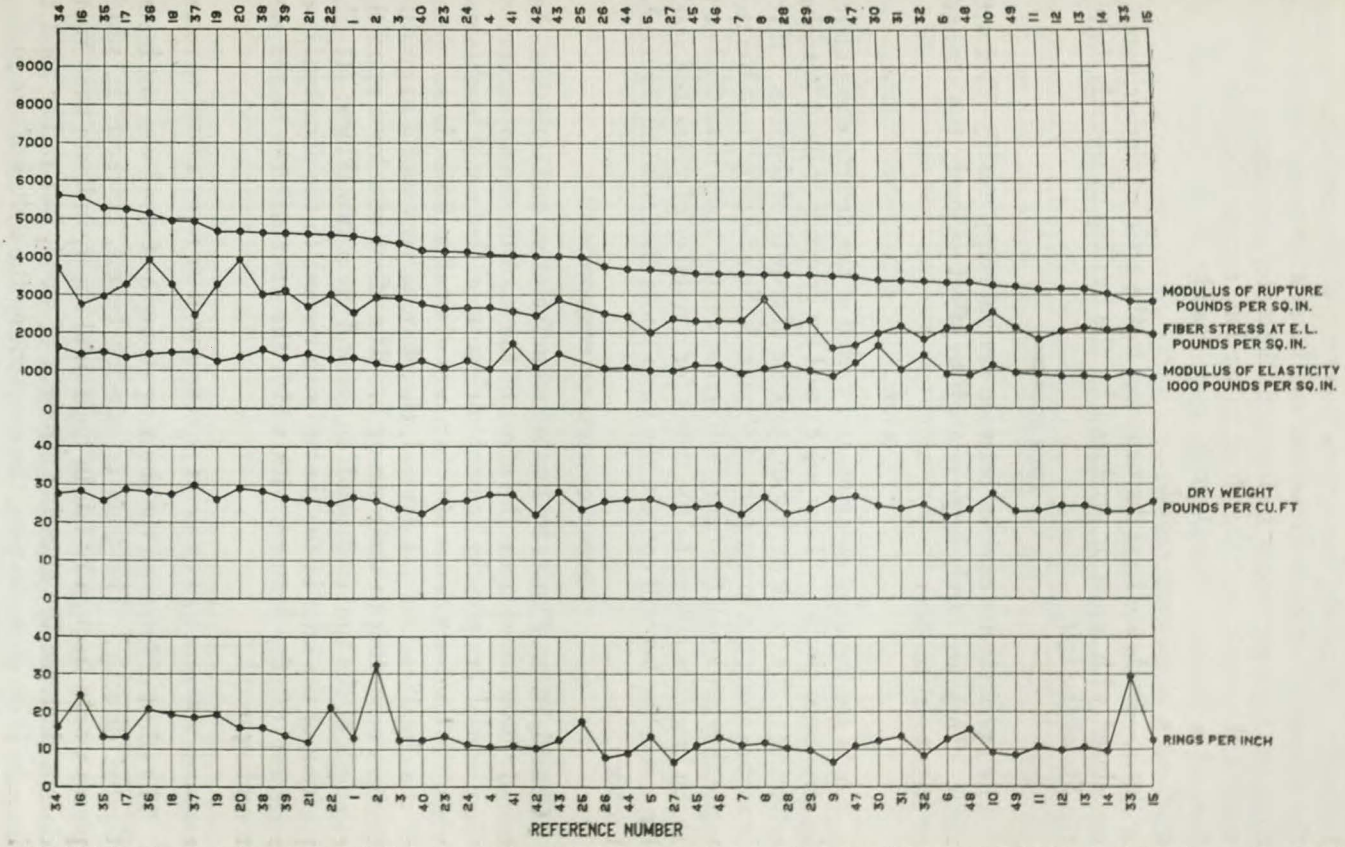


FIG. 26.—Modulus of rupture, fiber stress at elastic limit, modulus of elasticity, dry weight per cubic foot, and rings per inch for structural sizes of green Norway pine.

not show in the so-called visible grain of the wood, which in softwood lumber is nothing but a sectional view of the annual rings cut longitudinally. A careful inspection, however, of the medullary rays on the tangential or bastard section will invariably reveal spiral grain, since the rays necessarily incline with the spiral direction of the fibers around the trunk, and therefore, in section, appear obliquely on the face of a timber. Spiral grain may readily be detected also by splitting a small piece radially.

Burls.—Burls are local disturbances in the grain of timber, usually associated with knots or produced by the healing of wounds during the life of the tree.

PITCH POCKETS.

Pitch pockets are cavities between annual rings, usually filled with resin. They are rarely large enough to affect seriously the strength of structural timbers.

KNOTS.

Knots are the most common and varied of the defects encountered in structural timber. They are caused by growing or dead branches adhering to the trunk during the process of growth of the tree. If the branches along the lower part of the trunk die and drop from the tree while they are small the trunk will contain small knots near the heart. If the branches adhere to the trunk for a number of years and reach large size the log will contain the large knots that weaken structural timber.

EFFECT OF KNOTS ON STRENGTH.

Classification of knots by lumber manufacturers and consumers has usually been based upon the effect of the knot on the appearance of the material, or upon the amount of clear wood that could be obtained when the lumber was cut up into pieces of smaller dimensions. None of the classifications yet devised, therefore, is very useful in grading timbers according to their strength. The effect of a knot upon the strength of the timber depends in general upon two things: (1) The position of the knot in the timber with respect to the distribution of stresses; (2) the firmness with which the knot adheres to the surrounding wood.

SHEARING STRENGTH AND STRENGTH IN COMPRESSION AT RIGHT ANGLES TO GRAIN.

The effect of knots on the shearing strength of wood was not investigated directly. The tests on air-dry beams, however, in which pieces would frequently fail in horizontal shear, indicate that knots do not decrease the shearing strength of wood, but rather tend to increase it by acting as pins, thus preventing the sliding of one surface over the other. Knots have also practically no influence in decreasing

the strength in compression at right angles to grain, since almost invariably the wood of a sound knot is harder than the surrounding wood.

STRENGTH IN COMPRESSION PARALLEL TO GRAIN.

Table 5 shows, for Douglas fir, western hemlock, and western larch, to what extent the maximum crushing strength, the crushing strength at elastic limit, and the modulus of elasticity in compression parallel to the grain are affected by knots. It will be seen that in short timbers 6 inches by 6 inches in cross section, upon which the table is based, the mechanical properties in compression parallel to grain are decreased approximately 5 per cent by knots ½ inch or less; from 10 to 15 per cent by knots between ½ and 1½ inches; and from 15 to 20 per cent by knots greater than 1½ inches diameter. Analyses of similar tests on the other species show approximately the same results. While the decrease in these functions seems to be more or less definitely associated with the presence of knots, it is without doubt due more to the difference in strength of the clear wood. Tests made on small clear specimens free from defects show that the wood obtained from top logs is both lighter and weaker than that from butt logs. The number and size of the knots in any particular piece of timber is one of the most reliable indications of the part of the tree from which the timber is cut. When knots are large and comparatively numerous it indicates that the timber was cut from near the top of the tree or from a tree growing in the open.

GENERAL EFFECT OF KNOTS ON BEAMS.

The Forest Service tests have shown that the maximum strength in compression parallel to grain is one of the most reliable indications of the general mechanical properties of wood uninfluenced by defects In figures 19, 20, and 21 the large beams are arranged in order of their modulus of rupture, and the fiber stress at elastic limit and the modulus of elasticity are shown for each test on the same vertical line with the modulus of rupture. The maximum crushing strength and the modulus of elasticity in bending obtained from small clear specimens cut from each of the large timbers tested are also indicated. The tests bring out the following points:

(1) The modulus of elasticity for the large beams and that for the small clear beams cut from them are approximately equal. This would indicate that the modulus of elasticity is not influenced by the presence of defects in the large specimens. In other words, knots do not affect the stiffness of structural timbers, this factor apparently being dependent almost entirely upon the quality of the clear wood.

(2) The fiber stress at elastic limit for large beams does not vary directly with the modulus of rupture, but is, except in the weakest timbers, practically equal to the crushing strength of the small clear specimens. This indicates that the elastic limit of timber beams is affected only by defects of the most serious character.

(3) The tables in the Appendix show that, for large beams, the modulus of rupture decreases as the number and seriousness of defects increase, and the diagrams show that as it decreases it approaches in value the fiber stress at elastic limit of the beam and the maximum crushing strength of the clear wood. Only in the weakest timbers does it fall below the last.

These facts seem to indicate conclusively that the stiffness and elastic strength of timber beams are more dependent upon the quality of the wood fiber than upon the number and character of defects which the beam contains. The modulus of rupture, however, seems to be very susceptible to the influence of defects. To be more accurate, the property of a timber beam most influenced by defects is the difference between its fiber stress at elastic limit and its modulus of rupture. This difference might be termed the reserve strength of the timber.

FAILURES IN TIMBER BEAMS.

A first failure in a timber under test is significant in that it shows the point of greatest weakness in the specimen when it is subjected to the conditions of loading used in the test. The three types of failures observed in the tests on beams are as follows:

COMPRESSION FAILURE.

Compression failure consists in the buckling of the fibers in the upper half of the beam. This usually begins on the top side shortly after the elastic limit is reached and extends downward, sometimes almost reaching the neutral axis before complete failure occurs. Frequently two or more failures develop almost simultaneously.

TENSION FAILURE.

When the fibers on the bottom side of the beam are torn apart like fibers in a piece of string the result is called a tension failure. When the timber under test has diagonal or spiral grain, or when it contains a burl, the internal stress develops a tensile force which acts at right angles to the grain. Wood, especially that of the straight-grained conifers, which split easily, is comparatively weak in tension so applied. Therefore, when the wood is subjected to tensile stresses which have a component acting at right angles to the grain, failure in cross-grain tension almost invariably results.

HORIZONTAL SHEAR.

Sometimes the beam under load splits, usually from one end of the beam to the middle, or in some cases from both ends. This is called failure in horizontal shear. Such failures are comparatively common in air-dry material and in green material when the ratio of the height of beam to the length of span is relatively large.

ANALYTICAL STUDY OF FAILURES.

To determine the relative importance of defects in different parts of timber beams the beam was theoretically divided into three parts or volumes, as indicated in figure 27. Volume 1 includes the middle

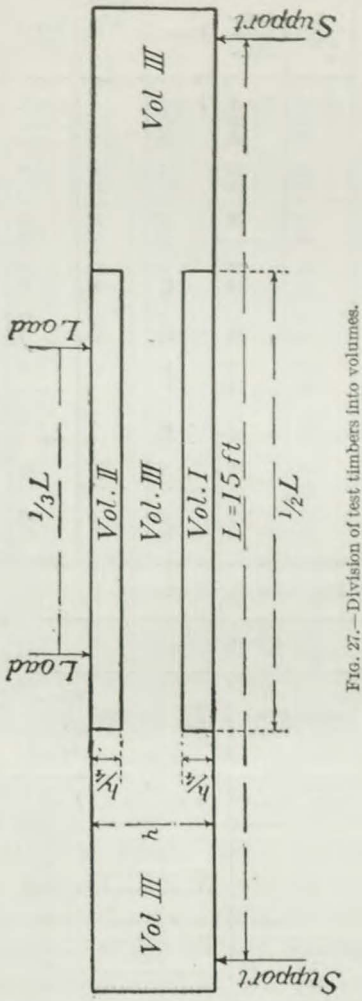


FIG. 27.—Division of test timbers into volumes.

half of the tension face and extends one-fourth of the height of the beam toward the neutral axis. Volume 2 includes the middle half of the compression face and extends one-fourth of the height toward the neutral axis. Volume 3 includes the remainder of the beam.

TABLE 6.—*Analysis of causes of failure in large beams, expressed in terms of number of tests.*

Species.	Total number of tests.	Total number failing by—			First failure by tension.					
					Number.	Failure due to—				
		Tension.	Compression.	Shear.		Large knots.	Small knots.	Irregular grain.	Pitch pocket.	Nothing apparent.
		Per ct.	*Per ct.*	*Per ct.*		*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*
Longleaf pine:										
Green	17	18	24	58	3	.....	.....	.....	.....	100
Dry	9	22	22	56	2	.....	.....	.....	.....	100
Douglas fir:										
Green	191	27	72	1	51	43	8	37	.....	12
Dry	91	19	76	5	17	18	18	58	.....	6
Shortleaf pine:										
Green	48	27	56	17	13	23	15	46	.....	16
Dry	13	54	.....	46	7	29	.....	29	.....	42
Western larch:										
Green	62	23	71	6	14	29	21	43	.....	7
Dry	52	54	19	27	28	18	18	39	.....	25
Loblolly pine:										
Green	111	40	53	7	44	27	11	52	2	8
Dry	25	60	12	28	15	7	.....	46	.....	47
Tamarack:										
Green	30	37	53	10	11	18	36	18	.....	28
Dry	9	45	22	33	4	.....	.....	50	.....	50
Western hemlock:										
Green	39	21	74	5	8	75	.....	.....	12	13
Dry	44	11	66	23	5	.....	20	40	.....	40
Redwood:										
Green	28	43	50	7	12	25	.....	17	.....	58
Dry	12	83	17	.....	10	.....	10	10	.....	80
Norway pine:										
Green	49	18	76	6	9	67	.....	11	.....	22
Dry	10	30	60	10	3	67	.....	.....	.....	33

Species.	First failure by compression.						First failure by shear.				
	Number.	Failure due to—					Number.	Failure due to—			
		Large knots.	Small knots.	Irregular grain.	Rotten streak.	Nothing apparent.		Checks.	Pitch pocket.	Rotten streak.	Nothing apparent.
		Per ct.	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*		*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*
Longleaf pine:											
Green	4	25	.....	.....	.....	75	10	90	.....	.....	10
Dry	2	.....	.....	.....	.....	100	5	100	.....	.....	.....
Douglas fir:											
Green	137	12	17	.....	.....	71	3	.....	33	.....	67
Dry	69	1	3	.....	.....	96	5	.....	20	.....	80
Shortleaf pine:											
Green	27	7	.....	4	.....	89	8	.....	.....	.....	100
Dry	.....	.....	.....	.....	.....	.....	6	100	.....	.....	.....
Western larch:											
Green	44	2	18	.....	.....	80	4	50	.....	.....	50
Dry	10	20	10	.....	.....	70	14	100	.....	.....	.....
Loblolly pine:											
Green	59	25	2	7	.....	66	8	38	.....	.....	62
Dry	3	33	.....	.....	.....	67	7	86	.....	.....	14
Tamarack:											
Green	16	12	37	6	.....	45	3	.....	.....	67	33
Dry	2	.....	50	.....	.....	50	3	100	.....	.....	.....
Western hemlock:											
Green	29	7	3	.....	3	87	2	50	.....	.....	50
Dry	29	10	.....	.....	.....	90	10	100	.....	.....	.....
Redwood:											
Green	14	14	.....	.....	.....	86	2	.....	.....	.....	100
Dry	2	.....	.....	.....	.....	100	0	.....	.....	.....	.....
Norway pine:											
Green	37	19	32	.....	.....	49	3	67	.....	.....	33
Dry	6	.....	50	.....	.....	50	1	100	.....	.....	.....

TABLE 7.—*Analysis of causes of failure in large beams, expressed in terms of modulus of rupture.*

Species.	Average modulus of rupture per square inch.	Modulus of rupture in per cent of average green modulus of rupture.																
		First failure by tension (per cent).						First failure by compression (per cent).						First failure by shear (per cent).				
		All tension failures.	Failure due to—					All compression failures.	Failure due to—					All shear failures.	Failure due to—			
			Large knots.	Small knots.	Irregular grain.	Pitch pockets.	Nothing apparent.		Large knots.	Small knots.	Irregular grain.	Rotten streaks.	Nothing apparent.		Checks.	Pitch pockets.	Rotten streaks.	Nothing apparent.
Longleaf pine:	*Pounds.*																	
Green	6,140	112	....	....	....	....	112	102	118	....	....	....	97	94	95	....	....	91
Dry	5,749	121	....	....	....	....	121	128	....	....	....	....	128	69	69	....	....	....
Douglas fir:																		
Green	5,983	83	82	80	77	....	104	107	102	97	....	....	110	66	....	70	....	64
Dry	6,372	82	69	78	82	....	136	113	98	103	....	....	114	94	....	86	....	96
Shortleaf pine:																		
Green	5,548	94	76	90	100	....	109	103	87	....	91	....	105	99	....	....	....	99
Dry	6,573	117	96	....	115	....	132	....	....	....	....	....	....	121	121	....	....	....
Western larch:																		
Green	4,948	73	166	77	71	....	100	109	116	99	....	....	111	92	109	....	....	75
Dry	5,856	110	102	112	103	....	124	146	155	139	....	....	145	116	116	....	....	....
Loblolly pine:																		
Green	5,084	86	73	86	90	90	98	109	96	94	101	....	115	112	112	....	....	112
Dry	6,118	120	39	....	114	....	138	121	140	....	....	....	112	120	120	....	....	120
Tamarack:																		
Green	4,556	90	71	90	96	....	98	106	93	104	81	....	116	102	....	....	105	96
Dry	5,498	106	....	....	112	....	100	156	....	147	....	....	164	117	117	....	....	....
Western hemlock:																		
Green	5,296	74	71	....	....	85	81	107	105	133	....	95	106	108	134	....	....	82
Dry	6,420	108	....	92	106	....	119	134	129	....	....	....	134	91	91	....	....	....
Redwood:																		
Green	4,472	81	77	....	55	....	90	116	103	....	....	....	119	100	....	....	....	100
Dry	3,891	80	....	58	48	....	87	122	....	....	....	....	122	....	....	....	....	....
Norway pine:																		
Green	3,864	94	94	....	73	....	105	105	92	98	....	....	114	107	100	....	....	121
Dry	6,054	134	136	....	....	....	129	169	....	136	....	....	201	155	155	....	....	....

Table 6 shows what percentage of the timbers tested failed first in tension, compression, and horizontal shear, and the defects to which the failures were apparently due. The following example will illustrate the manner in which it can be used. The figures for loblolly pine show that of 111 green beams tested 40 per cent, 53 per cent, and 7 per cent failed, respectively, in tension, compression, and horizontal shear. Reference to the more detailed data on tension failures will show that 27 per cent of the tension failures were due to large knots, 11 per cent to small knots, 52 per cent to irregular grain, 2 per cent to pitch pockets, and 8 per cent to no apparent cause. In the same manner the cause of the compression and horizontal shear failures are indicated. The table also permits a direct comparison of the failures in green and in air-seasoned timbers. A study of it brings out the following points:

(1) Of green timbers from 18 to 43 per cent fail first in tension, from 50 to 75 per cent in compression, and from 1 to 17 per cent in horizontal shear. Of air-seasoned timbers from 11 to 83 per cent fail first in tension, from 12 to 76 per cent in compression, and from 5 to 56 per cent in horizontal shear. By comparing the percentages for

the green and air-seasoned timbers of each species it is seen that seasoning increases greatly the liability of failure in tension and horizontal shear.

(2) In the great majority of cases tension failures were due to knots or irregular grain in volume 1. This is especially noticeable in green timbers, where the percentage of tension failures not apparently due to a defect is generally smaller than in air-seasoned material.

(3) Compression failures in a remarkably large proportion of both green and air-seasoned material were apparently not influenced by any defect. Although in the case of timbers with one or more knots in volume 2 compression failure could, in a considerable number of cases, be traced to the knots, in others it seemed to be uninfluenced by them.

(4) In spite of the fact that a large percentage of the horizontal shear failures in green timbers are recorded as not being influenced by any apparent defect it is probable that timber beams of the dimensions and under the conditions of loading used in these tests would not fail in horizontal shear unless the calculated area resisting shear was appreciably decreased by defects, such as checks or shakes. This is strongly indicated by the greater proportion of horizontal shear failures in the seasoned timbers and by the fact that, except in the case of Douglas fir, practically all the horizontal shear failures in the seasoned timbers were due to checks. In green timbers, however, checks and shakes are usually not visible, which would explain why, in their case, the failures are not attributed to such defects.

To determine which class of defects most seriously affects the strength of timber, Table 7 was compiled. In the second vertical column is given the average modulus of rupture for all green timbers tested for each species. The other figures express as a percentage of this value the average modulus of rupture of the timbers failing from any particular class of defects. For example, in the tests on loblolly pine it will be seen that the average modulus of rupture for the green beams which failed first in tension was 86 per cent, that of beams which failed in tension due to large knots was 73 per cent of the average for all green beams tested. The table brings out the following points:

(1) The average modulus of rupture for green beams that fail first in tension due to defects in volume 1 is almost invariably lower than the average for all beams tested.

(2) In the beams failing by tension, when the failure was not apparently due to a defect, the average modulus of rupture is, except in the case of green western hemlock, practically equal to the average for all beams tested.

(3) The average modulus of rupture for air-seasoned timbers failing first in tension is generally higher than the average for the green timbers tested. The exceptions to this are some of the cases where the failure was due to defects in volume 1.

(4) The average modulus of rupture of beams that failed first in compression is almost invariably higher than the average for all beams of the species, this being true even in the classes where the failures were due to defects in volume 2.

(5) In the great majority of cases the average modulus of rupture of air-seasoned beams that failed first in horizontal shear is greater than or only slightly less than the average for all green beams. The tests on longleaf pine are the exception to this rule, but only five such tests were made, and the timbers contained numerous checks of a rather serious character.

The principal conclusion to be drawn from this analysis of failure is that the only defects of the classes here discussed which can be

counted upon seriously to weaken a timber beam are large knots or irregular grain occurring in volume 1.

GRADING OF TIMBER BEAMS ACCORDING TO THEIR MECHANICAL PROPERTIES.

It is only within the last decade that engineers and architects have given much consideration to the grading of structural timbers. Before that time structural timbers practically free from serious defects could readily be obtained. With the depletion of the virgin forests, however, the quality of structural timbers has steadily decreased, and to-day it is necessary to accept timbers containing defects which were formerly excluded. Lumber-manufacturing associations have done much to standardize the grading rules for different species and classes of timber. In general, however, these grading rules are based entirely upon the number and character of defects, and while they have proved fairly satisfactory in grading sawmill products for the woodworking industries, they are not very effective in separating structural timbers according to their strength.

The American Society for Testing Materials was the first technical association to formulate a specification for structural timber in which the position of defects was considered. This specification was based on tests on structural timbers made by the Forest Service and other agencies. The American Railway Egineering Association recently adopted standard specifications for yellow pine and Douglas fir which differ from those of the American Society for Testing Materials only in minor details. Forest Service Bulletin 88, "Properties and Uses of Douglas Fir," pages 40 to 48, inclusive, shows that although these specifications are a great improvement over others mentioned in the bulletin, they are unsatisfactory in that they cull much material which under test proves to be as strong as that admitted into the acceptable grades.

One of the aims of the bulletin is to apply the results presented to the problem of better grading rules, and the purpose in correlating physical characteristics and defects with mechanical properties has been to show which factors are the most indicative of the mechanical properties of structural timbers. In this connection, the results emphasize the following points:

(1) The mechanical properties of timber beams are dependent upon: *a*. The quality of the wood irrespective of defects; *b*. the character and location of defects.

(2) The mechanical properties of wood free from defects vary directly with its dry weight. The relative dry weight of the different pieces of wood of any species can be approximated by comparing the proportion of summerwood in each.

(3) The only defects which materially decrease the breaking strength of timber beams are the more serious ones, such as large knots and cross grains occurring where fibers are subjected to comparatively high stresses.

(4) All the species tested seem to be subject to the same general laws regarding the relation of mechanical to physical properties.

On the basis of these four general conclusions the attempt is made to formulate a set of definitions and rules which can be applied to the grading of structural timbers cut from any of the species discussed in this bulletin. It is too much to hope that these will eliminate entirely the judgment of the grader or inspector, but they should be of assistance in bringing about a simpler and more satisfactory system of grading than now exists.

DEFINITIONS.

DENSE WOOD.

The term "dense wood" will be used to define the quality of wood which is desirable in timbers subjected to stresses such as occur in frame structures. The term applies to the wood itself, irrespective of defects. Since dry weight, which is the most accurate index to the mechanical properties of wood, can not be determined from a casual inspection of the timber, dense, or in other words, comparatively heavy wood will be defined as:

(1) Wood that shows more than eight rings per inch, or the rings of which contain more than 30 per cent summerwood.

(2) Wood which is resilient; that is, which when struck with a hammer or similar blunt instrument, gives a sharp, clear sound, while the hammer shows a marked tendency to rebound and the wood to recover from the effects of the blow.

These properties are to be judged from an inspection of the cross section of the timber.

KNOTS.

Knots are portions of branches which have been encased in the growing trunk of the tree. In judging their effect upon the strength of a timber it should be borne in mind that the axis of a knot always extends to the center or pith of the tree,[1] and that the visible part of the knot is a section of a somewhat conical mass of wood, the apex of the cone being at the pith of the tree, and the knot as a whole more or less securely intertwined with the wood surrounding it. A spike knot is a longitudinal section of a whole knot, and a round or elliptical knot is a section, respectively, at right angles or at some oblique angle, to the axis of the knot. Sound knots, as a rule, are stronger and harder than the wood fiber surrounding them. Their effect, therefore, upon the strength of the timber depends to a large extent upon the manner in which they are connected to the surrounding wood and upon the degree of stress to which the connecting fibers are subjected. If knots disturb the grain so that it is decidedly oblique to the edges of the timber the wood will be subjected to stresses in tension at right angles to the grain, the kind to which it offers the least

[1] Exceptions to this rule are knots caused by adventitious branches, but such exceptions are so rare that they can be ignored in the grading of structural timbers.

resistance. In such cases early failure in cross-grain tension almost invariably results.

Class 1 knots.—Class 1 knots must be solid, firmly attached to the surrounding wood, and cause no marked irregularity in the grain of the timber. Small spike knots will be included in this class.

Class 2 knots.—Class 2 knots must be solid, but are insecurely attached to the surrounding wood, or associated with burl or other irregularity in the grain.

Class 3 knots.—Class 3 knots are unsound knots; that is, they are softer than the surrounding wood.

Diameter of knots.—The diameter of a knot on the narrow faces of a timber will be its projection on a line perpendicular to an edge of the timber. On the wide or vertical faces the smallest dimension of a knot is to be taken as its diameter.

Small knots.—Knots less than 1½ inches in diameter.

Large knots.—Knots 1½ inches or more in diameter.

POSITION OF DEFECTS.

The position of defects is designated by means of volumes indicated in figure 27.

Other terms used in the tentative grading rules which follow are found under "Defects," page 42.

TENTATIVE GRADING RULES.[1]

GRADE 1 TIMBERS.

(*a*) Must contain only dense wood.

(*b*) Must not have class 2 or large class 1 knots in volume 1.

(*c*) Must not have large class 2 knots in volume 2.

(*d*) The aggregate diameter of knots on any face within the center half of the length shall not exceed the width of the face.

(*e*) Must not have shakes or deep checks.

(*f*) Must not have diagonal grain with a slope greater than 1 inch in 20.

GRADE 2 TIMBERS.

(*a*) Must contain only dense wood.

(*b*) Must not have large class 2 knots in volume 1.

(*c*) The aggregate diameter of knots on any face in the center half of the length shall not exceed two times the width of the face.

(*d*) Must not have shakes which extend along an annual ring a distance greater than the width of the piece.

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[1] It should be understood that these tentative rules are for the purpose of strength classification only and do not take into account requirements of a general nature such as conformity to dimensions, proportion of sap or other requirements made necessary by peculiarities of certain species.

APPLICATION OF TENTATIVE GRADING RULES TO TIMBER TESTED.

To test the efficiency of the rules just given the timbers were graded by means of sketches of each timber made before it was tested. The man who did the grading was ignorant of the actual strength developed by the different timbers. While the sketches did not contain data in sufficient detail to permit him to exercise his judgment to the extent possible in grading actual timbers, they were sufficiently accurate to permit the literal application of the grading rules with respect to the character and location of defects. The results of this test of the rules are indicated in figures 28 and 29. These show, respectively, the range in the modulus of rupture and fiber stress at elastic limit for the different grades of each species tested. The range is indicated by the scale to the left. The length of the shaded portion of the diagrams between any two horizontal lines is proportional to the percentage of the total number of tests that fell within the limits indicated on the scale to the left. For each species, the areas on the right-hand side of the vertical lines, crosshatched downward to the left, show the range in strength and distribution of timbers falling in grade 1; while the area on the same side of the vertical lines, with crosshatching downward to the right, show the corresponding factors for the timbers culled by the grading rules. The double crosshatched areas show to what extent the range of grade 1 timbers and culls overlap. The black areas to the left of the vertical lines show the range and distribution of timbers falling in grade 2.

These diagrams show rather conclusively that the same grading rule may be applied to any of the species tested with approximately the same results, so far as classifying timbers according to strength is concerned. The limits of each of the grades and the average for each grade vary with the different species. It is especially noticeable, however, that, except for western larch, grade 1 timbers show a modulus of rupture of 4,000 pounds per square inch or greater. Also, that grade 1 timbers differ more with respect to the maximum values and the proportion of strong sticks that fall in the grade than they do with respect to the minimum values shown.

It will be noticed that in western larch, western hemlock, and redwood, no specimens are culled, although much of this material is weaker than timbers culled in other species. This is largely due to the fact that the sketches of the timbers tested did not permit the application of the "dense wood" clause in the grading rules. Very often timbers cut from the outer portions of large overmature trees will be practically free from serious defects, but the wood will be comparatively weaker. Its slow growth and soft uniform texture, however, make it very valuable for many purposes where strength is not a criterion. It is to exclude such material that the clause

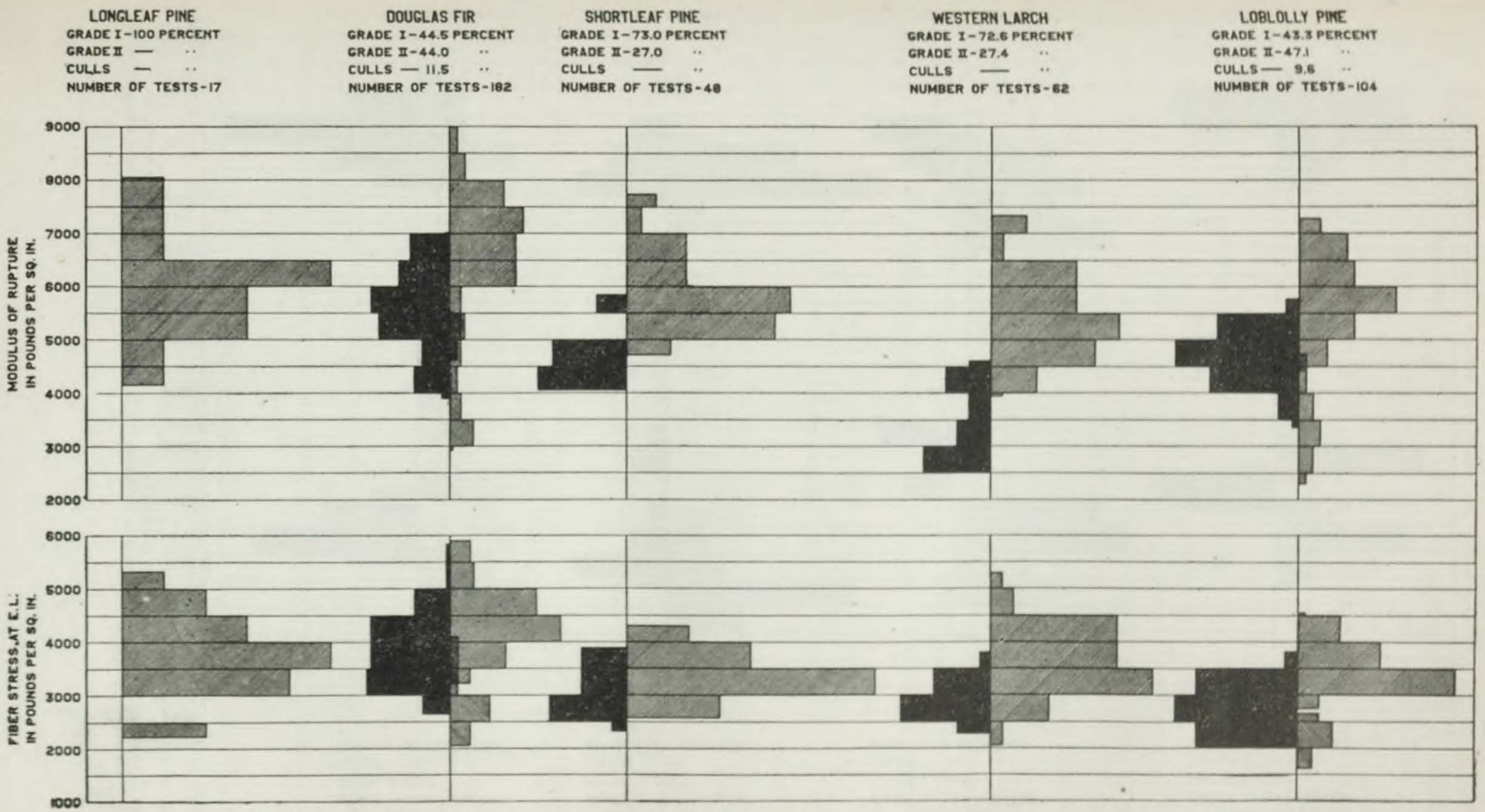

FIG. 28.—Variation in strength values in the different grades of longleaf pine, Douglas fir, western larch, and loblolly pine.

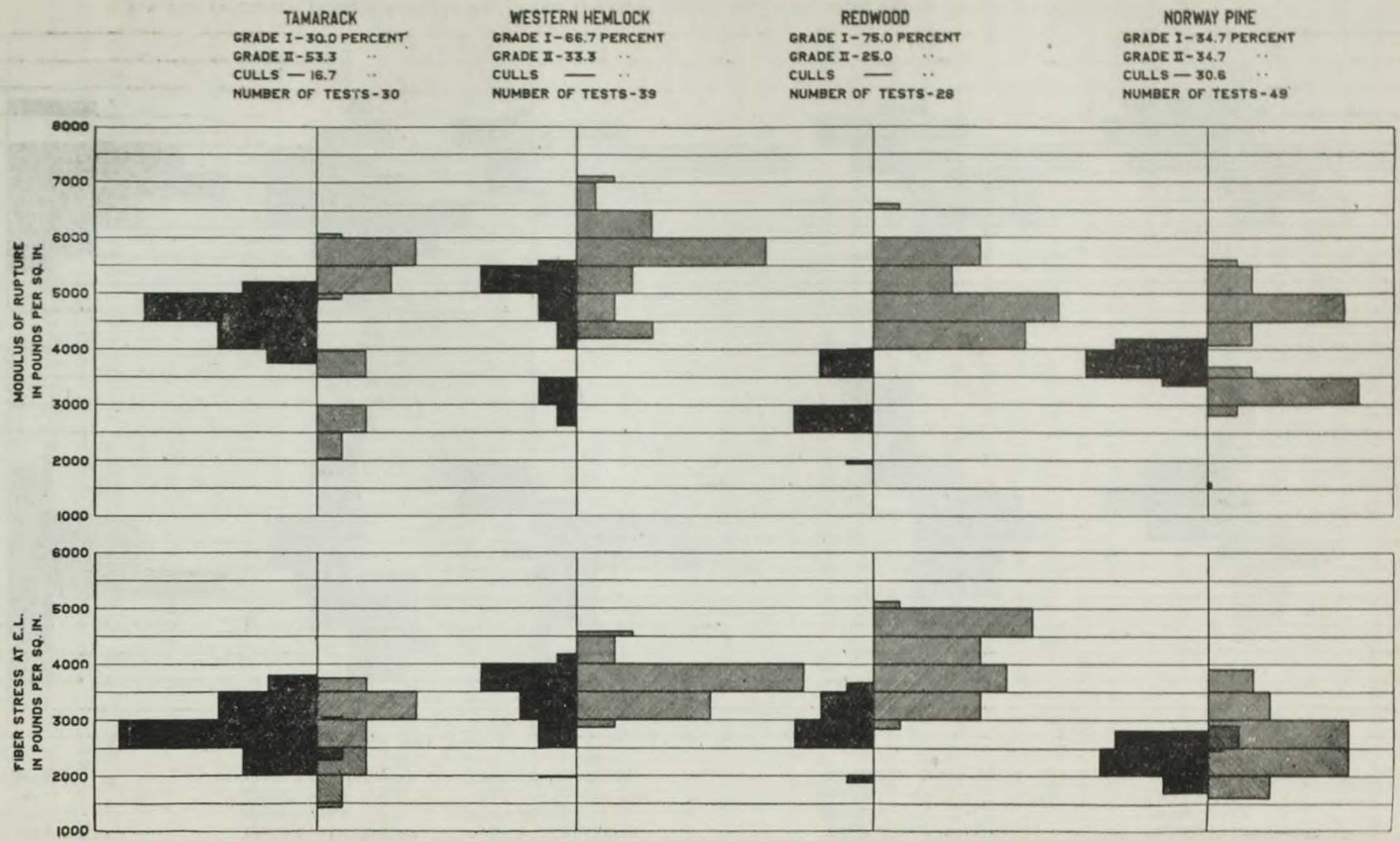

FIG. 29.—Variation in strength values in the different grades of tamarack, western hemlock, redwood, and Norway pine.

regarding "dense wood" was included in the grading rules. If this clause could have been applied, probably much of the western hemlock, western larch, and redwood falling in grade 2 would have been culled.

The efficiency of the tentative grading rules, however, can best be judged from their application to the Douglas fir and loblolly pine. A comparatively large number of beams of both of these species were tested, and special effort was made to have the samples represent the entire range in quality of material at all suitable for structural purposes. This was not done for the other species tested. Table 8 shows the total number of beams for each species considered in diagrams 28 and 29. It was not possible in all cases to include in this study the same number of timbers used in obtaining the general averages given in Tables 1 and 2, because some of the sketches were inadequate. Table 8 shows also the number of timbers of each species that fell into the respective grades, and the average values of the modulus of rupture, fiber stress at elastic limit, and modulus of elasticity for the different grades. The variation of individual results from the averages indicated in the table is shown in diagrams 4 and 12.

TABLE 8.—*Average strength values of different species by grades. (Timbers graded by proposed rules.)*

Species.	Number of tests.				Average modulus of rupture per square inch.			Average fiber stress at elastic limit per square inch.			Average modulus of elasticity per square inch.		
	Total.	Grade I.	Grade II.	Culls.	Grade I.	Grade II.	Culls.	Grade I.	Grade II.	Culls.	Grade I.	Grade II.	Culls.
					Lbs.	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*1,000 lbs.*	*1,000 lbs.*	*1,000 lbs.*
Longleaf pine	17	17	....	....	6,140	.....	.....	3,734	.....	.....	1,463	.....	.....
Douglas fir	182	81	80	21	6,919	5,564	4,174	4,402	3,831	2,914	1,643	1,468	1,206
Shortleaf pine	48	35	13	....	5,849	4,739	.....	3,318	3,005	.....	1,525	1,324	.....
Western larch	62	45	17	....	5,479	3,543	.....	3,662	2,432	.....	1,365	1,130	.....
Loblolly pine	104	45	49	10	5,898	4,702	3,416	3,513	2,793	2,258	1,535	1,309	1,149
Tamarack	30	9	16	5	5,469	4,525	3,008	3,151	2,847	2,097	1,276	1,261	991
Western hemlock	39	26	13	....	5,615	4,658	.....	3,689	3,172	.....	1,481	1,360	.....
Redwood	28	21	7	....	4,932	3,091	.....	4,031	2,947	.....	1,097	877	.....
Norway pine	49	17	17	15	4,821	3,764	3,255	3,082	2,364	2,144	1,373	1,204	962

COMPARISON OF TENTATIVE GRADING RULES WITH EXPORT GRADING RULES OF THE PACIFIC COAST LUMBER MANUFACTURERS' ASSOCIATION AND WITH THE STANDARD SPECIFICATIONS OF THE AMERICAN RAILWAY ENGINEERING ASSOCIATION.

On page 47 of Forest Service Bulletin 88, "Properties and Uses of Douglas Fir," is a diagram showing the application of the export grading rules of the Pacific Coast Lumber Manufacturers' Association and of the tentative standard specifications of the American Railway

Engineering Association to the Douglas-fir timbers tested. The application of the tentative grading rules suggested in this bulletin to the Douglas-fir timbers is shown in diagram 28. Table 9 compares the pertinent features of these three grading rules as applied to the Douglas-fir beams. The following points may be noted:

(1) The export rules of the Pacific Coast Lumber Manufacturers' Association throw 33.7 per cent of the timbers into the select grade, 43 per cent into the merchantable, and 21.2 per cent into the seconds. The standard specifications of the American Railway Engineering Association throw 31.1 per cent of the timbers into the first grade, 37.8 per cent into the second grade, and cull 31.1 per cent. The tentative grading rules proposed in this bulletin throw 44.5 per cent into the first grade, 44 per cent into the second, and cull 11.5 per cent. Although the number of culls is greatly decreased by the tentative grading rules, the range in strength shown by the different grades is not increased.

(2) The range in modulus of rupture for the first grade by the respective rules[1] is selects, from 9,000 pounds to 4,250 pounds per square inch; railroad No. 1, from 9,000 to 4,200 pounds; grade 1, from 9,000 to 4,600 pounds. The average for these three grades is, respectively, 6,700, 7,100, and 6,900 pounds per square inch. These figures indicate that although the tentative grading rules throw approximately 10 per cent more timbers in the first grade than either of the two other rules, this is done without increasing the range in strength of timbers included in the grade, and with only a slight reduction in the average from that for the railroad No. 1 grade.

TABLE 9.—*Comparison of grading rules as applied to Douglas fir.*

Grading rule and grade.	Total number.	Modulus of rupture per square inch.			Fiber stress at elastic limit per square inch.			Modulus of elasticity per square inch.		
		Average.	Maximum.	Minimum.	Average.	Maximum.	Minimum.	Average.	Maximum.	Minimum.
Export rules—Pacific Coast Lumber Manufacturing Co.:	*Per cent.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*1,000 lbs.*	*1,000 lbs.*	*1,000 lbs.*
Select	33.7	6,700	9,000	4,250	4,350	5,900	2,900	1,650	2,100	1,250
Merchantable	43.0	5,900	8,800	3,500	3,900	5,900	2,300	1,480	2,000	990
Second	21.2	5,200	8,300	2,900	3,500	5,800	2,100	1,330	1,900	800
Specifications—American Railway Engineering & Maintenance of Way Association:										
Railroad No. 1	31.1	7,100	9,000	4,200	4,520	5,900	2,900	1,680	2,100	1,100
Railroad No. 2	37.8	6,100	7,800	4,200	4,060	5,800	2,900	1,530	2,000	1,100
Culls	31.1	4,800	7,600	2,900	3,330	5,400	2,100	1,310	2,000	800
Proposed grading rules:										
Grade No. 1	44.5	6,900	9,000	4,600	4,400	5,920	3,230	1,640	2,070	1,100
Grade No. 2	44.0	5,600	7,000	3,900	3,800	5,860	2,650	1,470	1,900	1,020
Culls	11.5	4,200	5,500	2,900	2,900	4,100	2,050	1,200	1,500	800

(3) The extreme range in the modulus of rupture for the second grade is, respectively, merchantable from 8,800 to 3,500 pounds per square inch; railroad No. 2, from 7,800 to 4,200 pounds; grade No. 2, from 7,000 to 3,900 pounds. The average values for the three grades are, respectively, 5,900, 6,100, and 5,600 pounds. In this case, also, the range in strength is less by the proposed rules than in the corresponding grades by either of the two other rules, although the minimum is slightly less than the minimum for railroad No. 2. This indicates that the tentative grading rules have been effective in

[1] The grades specified by each of the three rules are shown in Table 9.

transferring from grade 2 to grade 1 a considerable number of strong sticks thrown into the second grade by both of the other rules.

(4) In the third grade under the Pacific Coast export rules (seconds) the extreme range for the modulus of rapture is from 8,300 to 2,900 pounds per square inch. In the pieces culled by the American Railway Engineering Association specifications, the extreme range is from 7,600 to 2,900 pounds per square inch, while in the specimens culled by the tentative grading rules the extreme range is from 5,500 to 2,900 pounds per square inch. The averages for these three groups are, respectively, 5,200, 4,800, and 4,200 pounds per square inch. These figures indicate that the tentative rules have been effective in greatly lessening the number of sticks culled by throwing many of the strong timbers culled by the two other rules either into grade 1 or grade 2.

(5) A similar study of the fiber stress at elastic limit and modulus of elasticity shows that the tentative rules have been more effective than either of the two others in grading timber according to these functions.

ADVANTAGES OF HAVING STANDARD GRADING RULES FOR STRUCTURAL TIMBERS.

Engineers and architects are at present unnecessarily confused by the different grading rules for structural timbers that have been adopted by various lumber manufacturers' associations. Often it is desired to use a new species for structural purposes, but with the present confusion in grading rules it is impossible for the purchaser to select a different species with any definite assurance that the grade of material he selects corresponds in strength with the grade of material he has been using. The tests discussed in this bulletin emphasize that timber beams, irrespective of species, are subject to the same general laws relating to the influence of defects and physical properties on the mechanical properties of the timber, and that all of the species considered in this bulletin can be separated into three fairly definite grades by the tentative rules given. If these or similar rules could be applied universally to the inspection and grading of structural timber it would do away with much of the uncertainty that at present exists regarding the properties of timbers sold for structural purposes, and would to a certain degree stimulate their use. Such rules, therefore, would seem to be to the advantage of both lumber manufacturer and consumer.

Another advantage of a uniform grading rule is that it permits more readily a comparison of timbers of various species and grades on the basis of relative strength. Table 8 gives the average strength, by grades, of the species studied. These species may be classified in order of strength as follows:

Class 1 timbers.—To include grade 1 timbers for longleaf pine, shortleaf pine, loblolly pine, and Douglas fir. Shortleaf pine and loblolly pine, however, generally contain quite a large proportion of sapwood, which is not nearly so durable as the heartwood. Therefore unless these species were treated with a preservative they should be excluded from this class and put into class 2.

Class 2 timbers.—To consist of grade 2 longleaf pine, grade 2 Douglas fir, grade 1 western larch and hemlock, and grade 1 tamarack.

Class 3 timbers.—To include grade 1 redwood, grade 1 Norway pine, grade 2 shortleaf pine, grade 2 loblolly pine, grade 2 tamarack, grade 2 western hemlock.

This classification, of course, is based entirely upon the strength developed by the timbers tested, and does not take into consideration other properties which may be desirable for any particular use. For example, the durability of the different species is influenced greatly by the amount of sapwood which the timbers contain. Shortleaf pine, loblolly pine, Norway pine, and tamarack usually contain a considerable proportion of sapwood. All of the other species mentioned in the table can be secured, as a rule, in dimension sizes practically free from sapwood.

APPENDIX.

FORMULÆ USED IN COMPUTATIONS.

LEGEND.

A=area of cross section, square inches.
B=area under plate, square inches.
CS=crushing strength, pounds per square inch.
E=modulus of elasticity, pounds per square inch.
EL=fiber stress at elastic limit, pounds per square inch.
J=greatest calculated longitudinal shear, pounds per square inch.
K=27.7 where weight is in pounds, and 0.061 where weight is in grams.
MR=modulus of rupture, pounds per square inch.
P=maximum load, pounds.
P'=load at elastic limit, pounds.
S=dry specific gravity.
W=weight of specimen, pounds.
$\triangle$=total deflection or compression at elastic limit, inches.
b=width, inches.
d=distance between centers of collars, inches.
h=height, inches.
l=span, inches (compression, l=length).

BENDING.

Load applied at center.

$$J=\frac{0.75\times P}{b\times h}$$

$$MR=\frac{1.5\times P\times l}{b\times h^2}$$

$$EL=\frac{1.5\times P'\times l}{b\times h^2}$$

$$E=\frac{P'\times l^3}{4\times b\times h^3\times\triangle}$$

Load applied at third points.

$$J=\frac{0.75\times P}{b\times h}$$

[1] $$MR=\frac{l\times(P+0.75\ W)}{b\times h^2}$$

[1] $$EL=\frac{l\times(P'+0.75\,W)}{b\times h^2}$$

$$E=\frac{P'\times l^3}{4.7\times b\times h^3\times\triangle}$$

COMPRESSION PARALLEL TO GRAIN.

$$CS=\frac{P}{A}\qquad EL=\frac{P'}{A}\qquad E=\frac{P'\times d}{A\times\triangle}$$

COMPRESSION PERPENDICULAR TO GRAIN.

$$EL=\frac{P'}{B}$$

SHEARING PARALLEL TO GRAIN.

$$\text{Shear}=\frac{P}{A}$$

SPECIFIC GRAVITY.

$$S=\frac{\text{wet weight}\times K}{(1+\text{per cent moisture})\times\text{volume in cubic inches.}}$$

[1] In large beams the weight should be taken into account in calculating the fiber stress. Three-fourths of the weight is added to the load for this reason.

TABLE 10.—*Average strength values for bending tests on green material of different sizes.*

Species.	Sizes.		Number of tests.	Moisture.	Rings per inch.	Fiber stress at elastic limit.		Modulus of rupture.		Modulus of elasticity.		Calculated shear.	
	Cross section.	Span.				Average per square inch.	Ratio to 2 by 2 inches.	Average per square inch.	Ratio to 2 by 2 inches.	Average per square inch.	Ratio to 2 by 2 inches.	Average per square inch.	Ratio to 2 by 2 inches.
	Ins.	*Ins.*		*P. ct.*		*Lbs.*		*Lbs.*		*1,000 lbs.*		*Lbs.*	
Longleaf pine	12 x 12	138	4	28.6	9.7	4,099	0.83	6,710	0.74	1,523	0.99	261	0.86
	10 x 16	168	4	26.8	16.7	4,193	.85	6,453	.71	1,626	1.05	306	1.01
	8 x 16	156	7	28.4	14.6	3,147	.64	5,439	.60	1,368	.89	390	1.29
	6 x 16	132	1	40.3	21.8	4,120	.83	6,460	.71	1,190	.77	378	1.25
	6 x 10	180	1	31.0	6.2	3,580	.72	6,500	.72	1,412	.92	175	.58
	6 x 8	180	2	27.0	8.2	3,735	.75	5,745	.63	1,282	.83	121	.40
	2 x 2	30	15	33.9	14.1	4,950	1.00	9,070	1.00	1,540	1.00	303	1.00
Douglas fir	8 x 16	180	191	31.5	11.0	3,968	.76	5,983	.72	1,517	.95	269	.81
	5 x 8	180	84	30.1	10.8	3,693	.71	5,178	.63	1,533	.96	172	.52
	2 x 12	180	27	35.7	20.3	3,721	.71	5,276	.64	1,642	1.03	256	.77
	2 x 10	180	26	32.9	21.6	3,160	.60	4,699	.57	1,593	1.00	189	.57
	2 x 8	180	29	33.6	17.6	3,593	.69	5,352	.65	1,607	1.01	171	.51
	2 x 2	24	568	30.4	11.6	5,227	1.00	8,280	1.00	1,597	1.00	333	1.00
Douglas fir (fire-killed).	8 x 16	180	30	36.8	10.9	3,503	.80	4,994	.64	1,531	.94	330	1.19
	2 x 12	180	32	34.2	17.7	3,489	.80	5,085	.66	1,624	.99	247	.89
	2 x 10	180	32	38.9	18.1	3,851	.88	5,359	.69	1,716	1.05	216	.78
	2 x 8	180	31	37.0	15.7	3,403	.78	5,305	.68	1,676	1.02	169	.61
	2 x 2	30	290	33.2	17.2	4,360	1.00	7,752	1.00	1,636	1.00	277	1.00
Shortleaf pine	8 x 16	180	12	39.5	12.1	3,185	.73	5,407	.70	1,438	1.03	362	1.40
	8 x 14	180	12	45.8	12.7	3,234	.74	5,781	.75	1,494	1.07	338	1.31
	8 x 12	180	24	52.2	11.8	3,265	.75	5,503	.71	1,480	1.06	277	1.07
	5 x 8	180	24	47.8	11.5	3,519	.81	5,732	.74	1,485	1.06	185	.72
	2 x 2	30	254	51.7	13.6	4,350	1.00	7,710	1.00	1,395	1.00	258	1.00
Western larch	8 x 16	180	32	51.0	25.3	3,276	.77	4,632	.64	1,272	.97	298	1.11
	8 x 12	180	30	50.3	23.2	3,376	.79	5,286	.73	1,331	1.02	254	.94
	5 x 8	180	14	56.0	25.6	3,528	.83	5,331	.74	1,432	1.09	169	.63
	2 x 2	28	189	46.2	26.2	4,274	1.00	7,251	1.00	1,310	1.00	269	1.00
Loblolly pine	8 x 16	180	17	45.8	6.1	3,094	.75	5,394	.69	1,406	.98	383	1.44
	5 x 12	180	94	60.9	5.9	3,030	.74	5,028	.64	1,383	.96	221	.83
	2 x 2	30	44	70.9	5.4	4,100	1.00	7,870	1.00	1,440	1.00	265	1.00
Tamarack	6 x 12	162	15	57.6	16.6	2,914	.75	4,500	.66	1,202	1.05	255	1.11
	4 x 10	162	15	43.5	11.4	2,712	.70	4,611	.68	1,238	1.08	209	.91
	2 x 2	30	82	38.8	14.0	3,875	1.00	6,820	1.00	1,141	1.00	229	1.00
Western hemlock	8 x 16	180	39	42.5	15.6	3,516	.80	5,296	.73	1,445	1.01	261	.92
	2 x 2	28	52	51.8	12.1	4,406	1.00	7,294	1.00	1,428	1.00	284	1.00
Redwood	8 x 16	180	14	86.5	19.9	3,734	.79	4,492	.64	1,016	.96	300	1.21
	6 x 12	180	14	87.3	17.8	3,787	.80	4,451	.64	1,068	1.00	224	.90
	7 x 9	180	14	79.8	16.7	4,412	.93	5,279	.76	1,256	1.18	199	.80
	3 x 14	180	13	86.1	23.7	3,506	.74	4,364	.62	947	.89	255	1.03
	2 x 12	180	12	70.9	18.6	3,100	.65	3,753	.54	1,052	.99	187	.75
	2 x 10	180	13	55.8	20.0	3,285	.69	4,079	.58	1,107	1.04	169	.68
	2 x 8	180	13	63.8	21.5	2,989	.63	4,063	.58	1,141	1.08	134	.54
	2 x 2	28	157	75.5	19.1	4,750	1.00	6,980	1.00	1,061	1.00	248	1.00
Norway pine	6 x 12	162	15	50.3	12.5	2,305	.82	3,572	.69	987	1.03	201	1.17
	4 x 12	162	18	47.9	14.7	2,648	.94	4,107	.79	1,255	1.31	238	1.38
	4 x 10	162	16	45.7	13.3	2,674	.95	4,205	.81	1,306	1.36	198	1.15
	2 x 2	30	133	32.3	11.4	2,808	1.00	5,173	1.00	960	1.00	172	1.00
Red spruce	2 x 10	144	14	32.5	21.9	2,394	.66	3,566	.60	1,180	1.02	181	.80
	2 x 2	26	60	37.3	21.3	3,627	1.00	5,900	1.00	1,157	1.00	227	1.00
White spruce	2 x 10	144	16	40.7	9.3	2,239	.72	3,288	.63	1,081	1.08	166	.83
	2 x 2	26	83	58.3	10.2	3,090	1.00	5,185	1.00	998	1.00	199	1.00

TABLE 11.—*Average strength values for compression parallel to grain, compression perpendicular to grain, and shearing tests on green material of different sizes.*

Species.	Sizes.		Number of tests.	Moisture.	Rings per inch.	Fiber stress at elastic limit.		Modulus of rupture.		Modulus of elasticity.		Calculated shear.	
	Cross section.	Span.				Average per square inch.	Ratio to 2 by 2 inches.	Average per square inch.	Ratio to 2 by 2 inches.	Average per square inch.	Ratio to 2 by 2 inches.	Average per square inch.	Ratio to 2 by 2 inches.
	Ins.	*Ins.*		*P. ct.*		*Lbs.*		*Lbs.*		*1,000 lbs.*		*Lbs.*	
Longleaf pine	8 x 16	180	5	22.2	16.0	3,390	0.50	4,274	0.37	1,747	1.00	288	0.75
	6 x 16	132	1	23.4	17.1	3,470	.51	6,610	.57	1,501	.86	388	1.01
	6 x 10	177	2	19.0	8.8	4,560	.68	7,880	.68	1,722	99	214	.56
	4 x 11	180	1	18.4	23.9	3,078	.46	8,000	.69	1,660	.95	251	.66
	6 x 8	177	6	20.0	13.7	4,227	.63	8,196	.71	1,634	.94	177	.46
	2 x 2	30	17	15.9	13.9	6,750	1.00	11,520	1.00	1,740	1.00	383	1.00
Douglas fir	8 x 16	180	91	20.8	13.1	4,563	.68	6,372	.61	1,549	.91	269	.64
	5 x 8	180	30	14.9	12.2	5,065	.76	6,777	.65	1,853	1.09	218	.52
	2 x 2	24	211	19.0	16.4	6,686	1.00	10,378	1.00	1,695	1.00	419	1.00
Shortleaf pine	8 x 16	180	3	17.0	12.3	4,220	.54	6,030	.50	1,517	.85	398	.98
	8 x 14	180	3	16.0	12.3	4,253	.55	5,347	.44	1,757	.98	307	.76
	8 x 12	180	7	16.0	12.4	5,051	.65	7,331	.60	1,803	1.01	361	.89
	5 x 8	180	6	12.2	22.5	7,123	.92	9,373	.77	1,985	1.11	301	.74
	2 x 2	30	67	14.2	13.7	7,780	1.00	12,120	1.00	1,792	1.00	404	1.00
Western larch	8 x 16	180	23	18.3	21.9	3,343	.57	5,440	.53	1,409	.90	349	.96
	8 x 12	180	29	17.8	23.4	3,631	.62	6,186	.60	1,549	.99	295	.81
	5 x 8	180	10	13.6	27.6	4,730	.80	7,258	.71	1,620	1.04	221	.61
	2 x 2	30	240	16.1	26.8	5,880	1.00	10,254	1.00	1,564	1.00	364	1.00
Loblolly pine	8 x 16	180	14	20.5	7.4	4,195	.81	6,734	.72	1,619	1.10	462	1.45
	6 x 16	126	4	20.2	5.0	2,432	.47	4,295	.46	1,324	.90	266	.84
	6 x 10	174	3	21.3	4.7	3,100	.60	6,167	.66	1,449	.99	173	.54
	4 x 12	174	4	19.8	4.7	2,713	.52	5,745	.61	1,249	.85	185	.58
	8 x 8	180	9	22.9	4.9	2,903	.56	4,557	.48	1,136	.77	93	.29
	6 x 7	144	2	21.1	5.0	2,990	.58	4,968	.53	1,286	.88	116	.36
	4 x 8	132	8	19.5	9.1	3,384	.65	6,194	.66	1,200	.82	196	.62
	2 x 2	30	123	17.6	6.6	5,170	1.00	9,400	1.00	1,467	1.00	318	1.00
Tamarack	6 x 12	162	5	23.0	15.1	3,434	.45	5,640	.43	1,330	.82	318	.75
	4 x 10	162	4	14.4	9.7	4,100	.54	5,320	.41	1,356	.84	252	.59
	2 x 2	30	47	11.3	16.2	7,630	1.00	13,080	1.00	1,620	1.00	425	1.00
Western hemlock	8 x 16	180	44	17.7	17.8	4,398	.69	6,420	.62	1,737	1.04	406	1.06
	2 x 2	28	311	17 9	19.4	6,333	1.00	10,369	1.00	1,666	1.00	382	1.00
Redwood	8 x 16	180	6	26.3	22.4	3,797	.79	4,428	.57	1,107	.96	294	1.05
	6 x 12	180	6	16.1	17.7	3,175	.66	3,353	.43	728	.64	167	.60
	7 x 9	180	6	15.9	15.2	3,280	.69	4,002	.51	1,104	.96	147	.53
	3 x 14	180	6	13.1	24.4	.....	.....	5,033	.64	.....	.....	291	1.04
	2 x 12	180	5	13.8	14.4	3,928	.82	5,336	.68	1,249	1.09	260	.93
	2 x 10	180	5	13.8	24.8	3,757	.79	4,606	.59	1,198	1.05	186	.67
	2 x 8	180	6	13.7	20.7	4,314	.90	5,050	.65	1,313	1.15	166	.60
	2 x 2	28	122	15.2	18.8	4,777	1.00	7,798	1.00	1,146	1.00	279	1.00
Norway pine	6 x 12	162	5	16.7	8.1	2,968	.56	5,204	.61	1,123	.97	286	1.02
	4 x 10	162	5	13.7	12.0	5,170	.98	6,904	.82	1,712	1.48	317	1.13
	2 x 2	30	60	14.9	11.2	5,280	1.00	8,470	1.00	1,158	1.00	281	1.00

TABLE 12.—*Average strength values for bending tests on air-seasoned material of different sizes.*

Species.	Compression parallel to grain.						Compression perpendicular to grain.					Shear.		
	Size of specimen.	Number of tests.	Moisture.	Crushing strength at elastic limit per square inch.	Modulus of elasticity per square inch.	Crushing strength at maximum load per square inch.	Stress area.	Height.	Number of tests.	Moisture.	Crushing strength at elastic limit per square inch.	Number of tests.	Moisture.	Shearing strength per square inch.
	Ins.		*P. ct.*	*Lbs.*	*1,000 lbs.*	*Lbs.*	*Ins.*	*Ins.*		*P. ct.*	*Lbs.*		*P. ct.*	*Lbs.*
Longleaf pine	4 x 4	46	26.3	3,480	.....	4,800	4 x 4	4	22	25.3	568	44	21.8	973
	2 x 2	14	34.7	.....	.....	4,400								
Douglas fir	6 x 6	515	30.7	2,780	1,181	3,500	4 x 8	16	259	30.3	570	531	29.7	765
	5 x 6	170	30.9	2,720	2,123	3,490								
	2 x 2	902	29.8	3,500	1,925	4,030								
Douglas fir (fire-killed).	6 x 6	108	34.8	2,620	1,801	3,290	6 x 8	16	24	33.7	368	77	35.8	631
	2 x 2	204	37.9	.....	.....	3,430								
Shortleaf pine	6 x 6	95	41.2	2,514	1,565	3,436	5 x 8	16	12	37.7	361	179	47.0	704
	5 x 8	23	43.5	2,241	1,529	3,423	5 x 8	14	12	42.8	366			
	2 x 2	281	51.4	.....	.....	3,570	5 x 8	12	24	53.0	325			
							5 x 5	8	24	47.0	344			
							2 x 2	2	277	48.5	400			
Western larch	6 x 6	107	49.1	2,675	1,575	3,510	6 x 8	16	22	43.6	417	179	40.7	700
	2 x 2	491	50.6	3,026	1,545	3,696	6 x 8	12	20	40.2	416			
							4 x 6	6	53	52.8	478			
							4 x 4	4	30	50.4	472			
Loblolly pine	8 x 8	14	63.4	1,560	365	2,140	8 x 4	8	16	67.2	392	121	83.2	630
	4 x 8	18	60.0	2,430	691	3,560	4 x 4	8	38	44.6	546			
	2 x 2	53	74.0	.....	.....	3,340								
Tamarack	6 x 7	4	49.9	2,332	1,432	3,032	.....	.....	.....	.....	.....	24	39.2	668
	4 x 7	6	27.7	2,444	1,334	3,360								
	2 x 2	165	36.8	.....	.....	3,190								
Western hemlock	6 x 6	82	46.8	2,905	1,617	3,355	6 x 4	6	30	48.7	434	54	65.7	630
	2 x 2	131	55.6	2,938	1,737	3,392								
Redwood	6 x 6	34	83.6	3,194	1,240	3,882	6 x 8	16	13	86.7	473	148	84.2	742
	2 x 2	143	72.1	3,490	1,222	3,980	6 x 6	12	14	83.0	424			
							6 x 7	9	13	74.7	477			
							6 x 3	14	13	75.6	411			
							6 x 2	12	12	66.5	430			
							6 x 2	10	11	55.0	423			
							6 x 2	8	12	56.7	396			
							2 x 2	2	186	75.5	569			
Norway pine	6 x 7	5	29.0	1,928	905	2,404	.....	.....	.....	.....	.....	20	26.7	589
	4 x 7	8	28.4	2,154	1,063	2,652								
	2 x 2	178	26.8	.....	.....	2,504								
Red spruce	2 x 2	58	35.4	.....	.....	2,750	2 x 2	2	43	31.8	310	30	32.0	758
White spruce	2 x 2	84	61.0	.....	.....	2,370	2 x 2	2	46	50.4	270	40	58.0	651

TABLE 13.—*Average strength values for compression parallel to grain, compression perpendicular to grain, and shearing tests on air-seasoned material of different sizes.*

Species.	Compression parallel to grain.						Compression perpendicular to grain.					Shear.		
	Size of specimen.	Number of tests.	Moisture.	Crushing strength at elastic limit per square inch.	Modulus of elasticity per square inch.	Crushing strength at maximum load per square inch.	Stress area.	Height.	Number of tests.	Moisture.	Crushing strength at elastic limit per square inch.	Number of tests.	Moisture.	Shearing strength per square inch.
	Ins.		*P. ct.*	*Lbs.*	*1,000 lbs.*	*Lbs.*	*Ins.*	*Ins.*		*P. ct.*	*Lbs.*		*P. ct.*	*Lbs.*
Longleaf pine	4 x 5	46	26.3	3,480	.....	4,800	4 x 5	4	22	25.1	572	52	20.2	984
Douglas fir	6 x 6	259	20.3	3,271	1,038	4,258	4 x 8	16	44	20.8	732	465	22.1	822
	2 x 2	247	18.7	3,842	1,084	5,002	4 x 8	10	32	18.1	584			
							4 x 4	8	51	20.2	638			
							4 x 4	6	49	24.0	613			
							4 x 4	4	29	24.8	603			
Shortleaf pine	6 x 6	29	15.7	4,070	1,951	6,030	8 x 5	16	4	17.8	725	85	.....	1,135
	2 x 2	57	14.2	.....	.....	6,380	8 x 5	14	3	16.3	757			
							8 x 5	12	5	15.1	730			
							5 x 5	8	6	13.0	918			
							2 x 2	2	57	13.9	926			
Western larch	6 x 6	112	16.0	.....	.....	5,445	8 x 6	16	17	18.8	491	193	15.0	905
	4 x 4	81	14.7	.....	.....	6,161	8 x 6	12	18	17.6	526			
	2 x 2	270	14.8	.....	.....	5,934	5 x 4	8	22	13.3	735			
Loblolly pine	6 x 6	23	.....	3,357	1,693	5,005	8 x 5	16	12	19.8	602	156	11.3	1,115
	5 x 5	10	22.4	2,217	545	2,950	8 x 5	8	7	22.9	679			
	4 x 8	8	19.4	3,010	633	3,920	4 x 5	8	8	19.5	715			
	2 x 2	69	.....	.....	.....	5,547								
Tamarack	6 x 7	3	15.7	2,257	1,042	3,323	2 x 2	2	57	16.2	697	60	14.0	879
	4 x 7	3	13.6	3,780	1,301	4,823								
	4 x 4	57	14.9	3,386	1,353	4,346								
	2 x 2	66	14.6	.....	.....	4,790								
Western hemlock	6 x 6	102	18.6	4,840	2,140	5,814	7 x 6	15	25	18.2	514	131	17.7	924
	2 x 2	463	17.0	4,560	1,923	5,403	6 x 6	6	26	16.8	431			
							4 x 4	4	6	15.9	488			
Redwood	6 x 6	18	16.9	.....	.....	4,276	8 x 6	16	5	25.4	548	95	12.4	671
	2 x 2	115	14.6	.....	.....	5,119	6 x 6	12	6	14.7	610			
							7 x 6	9	5	14.8	500			
							3 x 6	14	2	12.6	470			
							2 x 6	12	2	16.2	498			
							2 x 6	10	4	14.3	511			
							2 x 6	8	2	13.2	429			
							2 x 2	2	145	13.8	564			
Norway pine	6 x 7	4	15.2	2,670	1,182	4,212	2 x 2	2	36	10.0	924	44	11.9	1,145
	4 x 7	2	22.2	3,275	1,724	4,575								
	4 x 4	55	16.6	3,048	1,367	4,217								
	2 x 2	44	11.2	.....	.....	7,550								

TABLE 14.—*Data on individual bending tests of green timbers of commercial sizes.*

Species.	Size.	Reference number.	Moisture.	Dry weight per cubic foot.	Rings per inch.	Summer wood.	Sap.	Cross-section classification.	Modulus of rupture per square inch.	Fiber stress at elastic limit per square inch.	Modulus of elasticity per square inch.	Horizontal shear per square inch.	Number of knots.						Other defects.	Manner of failure.[1]	Cause of first failure.
													Vol. I.		Vol. II.		Vol. III.				
													Less than 1½ inches.	1½ inches and over.	Less than 1½ inches.	1½ inches and over.	Less than 1½ inches.	1½ inches and over.			
	Inches.		*P. ct.*	*Lbs.*		*P. ct.*	*P. ct.*		*Lbs.*	*Lbs.*	*1,000 lbs.*	*Lbs.*									
Longleaf pine	12 x 12	1	31.6	36.2	9.4	.....	2	3	8,060	4,145	1,660	345	....	....	....	....	....	....	Small checks	S. C.	Due to checks.
		2	24.5	33.1	10.0	.....	3	3	7,740	3,390	1,470	320	1	....	2	....	3	4	.....	T. C.	No apparent cause.
		3	30.1	33.6	.....	.....	0	3	6,205	5,325	1,796	227	....	....	....	....	....	....	.....	C. T.	Do.
		4	28.4	35.3	.....	.....	0	3	4,836	3,537	1,167	151	2	1	....	....	3	6	Checks	C. T.	Do.
Average			28.6	34.6	9.7	.....	1	.....	6,710	4,099	1,523	261									
Longleaf pine	10 x 16	5	24.5	34.3	25.4	.....	2	3	7,250	4,980	1,333	372	....	....	2	....	....	....	do	C. S.	Due to large knot on upper edge 6 inches from center.
		6	30.5	34.9	10.7	.....	5	3	6,860	4,750	1,595	326	....	....	....	....	....	....	do	C. S.	No apparent cause.
		7	25.5	47.4	18.0	.....	20	3	6,070	3,700	1,870	261	....	....	....	....	....	....	do	S.	Due to checks.
		8	26.9	39.9	12.6	.....	5	3	5,630	3,340	1,705	263	....	....	....	....	....	....	do	S. T. C.	Do.
Average			26.8	39.1	16.7	.....	8	.....	6,453	4,193	1,626	306									
Longleaf pine	8 x 16	9	26.1	33.7	16.0	.....	3	3	6,400	3,080	1,230	366	....	....	....	....	3	....	do	S.	Do.
		10	26.7	34.4	10.5	47	0	3	5,600	3,130	1,380	433	....	....	....	....	3	....	do	S.	Do.
		11	25.9	38.6	14.8	28	0	3	5,580	4,180	1,412	438	....	....	....	....	12	....	do	S. C.	No apparent cause.
		12	29.0	32.2	17.3	50	21	3	5,490	3,510	1,399	424	....	....	....	....	6	....	do	S.	Due to checks.
		13	34.4	36.8	15.0	28	0	3	5,460	2,220	1,305	321	4	1	1	....	17	2	.....	S.	Do.
		14	27.4	34.4	14.5	29	2	3	5,390	3,520	1,235	420	1	....	1	....	8	1	Pitch pockets	S. T.	Do.
		15	29.1	36.8	14.0	40	1	3	4,150	2,390	1,617	325	....	....	....	....	1	....	Checks	S. C.	Do.
Average			28.4	35.3	14.6	37	4	.....	5,439	3,147	1,368	390									
Longleaf pine	6 x 16	16	40.3	31.2	21.8	.....	13	3	6,460	4,120	1,190	378	....	....	....	....	5	1	.....	T. C. S.	Failed in sapwood.
Do	6 x 10	17	31.0	33.7	6.2	.....	6	3	6,500	3,580	1,412	175	....	1	2	2	3	7	.....	T.	No apparent cause.
Do	6 x 8	18	28.0	34.9	7.0	.....	19	3	6,040	4,200	1,313	127	....	3	....	1	2	13	.....	T. C.	Small corner knot 14 inches from center.
		19	25.9	31.8	9.5	.....	7	3	5,450	3,210	1,250	115	....	1	....	2	3	8	.....	C.	Large knot on top face 6 inches from center.

Average			27.0	33.3	8.2		13		5,745	3,735	1,282	121								
Douglas fir	8 x 16..	1	28.8	33.9	9.4	42	0	3	9,000	5,260	1,770	381					6	1		C.	No apparent cause.
		2	34.4	31.8	7.8	45	5	1	8,790	5,800	1,895	374	1				22	1		C. T.	Do.
		3	30.8	30.9	11.1	35	0	3	8,270	5,840	1,945	350	4		5	2	18	1	Heart shake	C. T.	Do.
		4	32.6	34.4	8.0	41	0	1	8,210	5,920	1,870	345	2		4		3	1		C.	Do.
		5	30.8	31.5	9.0	33	0	3	8,070	5,900	1,920	341					7			C. T.	Do.
		6	33.4	31.9	7.6	35	0	1	8,060	5,040	1,770	339			2		8			C. T.	Do.
		7	29.0	28.9	6.2	35	0	1	8,000	3,780	1,205	340	2		2		8	2		C. T. S.	Do.
		8	32.3	32.3	6.6	40	0	1	7,930	4,720	1,720	336			3	1	6	1		C. T.	Do.
		9	30.6	30.4	23.8	40	0	1	7,930	5,280	1,565	336								C. S.	Do.
		10	34.3	30.9	12.1	37	0	1	7,840	4,910	1,720	334	2			2	4	11		C. T.	Do.
		11	33.7	28.6	11.0	38	0	3	7,780	4,680	1,715	330					3			C. T.	Do.
		12	32.4	31.1	15.0	37	0	1	7,780	5,540	1,970	330					6			C.	Do.
		13	27.3	29.2	7.4	40	0	1	7,700	4,670	1,463	329			1		4			C.	Do.
		14	34.9	31.8	15.5	37	0	1	7,750	4,680	1,780	328			2		6	3		C. T.	Do.
		15	32.9	28.4	15.1	39	0	1	7,730	5,260	1,645	328					2	1		C.	Do.
		16	34.0	30.1	7.0		0	1	7,680	4,660	1,745	324	1		1	1	26			T. S.	Do.
		17	30.7	31.1	8.0		0	1	7,610	4,568	1,436	320			1	1	9	4		C. T.	Do.
		18	30.7	33.7	7.6	56	0	3	7,590	4,970	2,070	514					4			C. T.	Do.
		19	30.8	31.2	14.6	35	0	1	7,580	4,400	1,450	321	1	1	3	3	9	10	Pitch seams	C. S.	Do.
		20	29.1	29.5	7.0		0	3	7,560	4,310	1,875	320	2		1	1	7	2		C. T. S.	Do.
		21	32.4	28.2	6.6	28	0	1	7,430	4,280	1,480	314					7			C. T.	Do.
		22	30.9	32.1	10.1	38	0	1	7,400	5,020	1,650	313					2			C. T.	Do.
		23	27.4	32.3	13.3	40	0	3	7,400	4,070	1,835	315	1		5	1	19	11		C. T. S.	Due to large corner knot 6 inches from center.
		24	30.8	30.7	14.8	35	0	1	7,380	4,960	1,680	313			3		4	1		C. T.	No apparent cause.
		25	28.7	30.4	7.8	36	0	3	7,380	4,700	1,710	312					1	2		C. T.	Do.
		26	33.0	31.4	27.0	32	0	4	7,350	4,800	1,780	304			4		38			C. T. S.	Do.
		27	27.6	33.3	16.5	38	0	1	7,320	4,750	1,820	309					5			C. S.	Do.
		28	29.3	28.7	10.9	35	0	1	7,300	4,560	1,775	311					8	4		C. S.	Do.
		29	30.0	31.4	10.5	35	0	1	7,300	5,280	1,650	309					6			T. C.	Do.
		30	33.0	28.1	6.3	43	0	3	7,270	4,430	1,820	309	5	2	2		24	3		C. T.	Do.
		31	37.1	29.9	10.6	36	0	1	7,250	4,980	1,690	307					7			C. S.	Do.
		32	32.9	29.3	10.6	32	0	1	7,220	3,810	1,610	308	1		1		8	1		C.	Do.
		33	31.1	29.8	14.3	37	0	1	7,200	4,940	1,740	311	2				7	5		C. T.	Do.
		34	36.8	28.3	4.1	32	0	1	7,180	3,860	1,585	303	1	3	2		4	3		C. T.	Due to large knot 1 inch from center on top face.
		35	34.8	27.8	12.7	52	0	1	7,160	3,930	1,725	476	1				5	4		C. T. S.	No apparent cause.
		36	33.8	26.8	7.3	28	0	1	7,140	4,370	1,370	303			2		10			C. T.	Do.
		37	27.0	30.4	9.3	43	0	3	7,090	4,660	1,820	301	4	2			8	2		C. T.	Do.
		38	31.3	28.8	19.0		6	1	7,070	4,625	1,660	299					18			C. T.	Do.
		39	30.8	29.3	15.0		0	1	7,060	4,065	1,268	299			1		3	11		C. T.	Due to large knot near center on top face.
		40	32.8	28.3	10.2	36	0	3	7,020	4,690	1,425	297			4	1	6	10		C. T.	Due to 2 small knots near center on top face.
		41	30.7	28.9	9.0		0	3	7,015	3,788	1,900	297	1	1	2	2	6	8		C. S.	No apparent cause.
		42	33.2	28.4	10.0		0	1	6,980	4,390	1,547	295			2	1	14	8		C. T.	Do.
		43	31.1	28.9	19.1	31	0	4	6,960	3,790	1,575	296			4		7			C. T.	Do.
		44	30.8	27.6	17.1	36	0	3	6,950	4,110	1,560	296	2		1		13	1		C. T.	Do.

[1] C. indicates compression failure, T. tension failure, and S. horizontal shear failure. Failures are indicated in the order of their occurrence.

TABLE 14.—*Data on individual bending tests of green timbers of commercial sizes*—Continued.

Species.	Size.	Reference number.	Moisture.	Dry weight per cubic foot.	Rings per inch.	Summer wood.	Sap.	Cross-section classification.	Modulus of rupture per square inch.	Fiber stress at elastic limit per square inch.	Modulus of elasticity per square inch.	Horizontal shear per square inch.	Number of knots. Vol. I. Less than 1½ inches.	Vol. I. 1½ inches and over.	Vol. II. Less than 1½ inches.	Vol. II. 1½ inches and over.	Vol. III. Less than 1½ inches.	Vol. III. 1½ inches and over.	Other defects.	Manner of failure.	Cause of first failure.
	Inches.		*P. ct.*	*Lbs.*		*P. ct.*	*P. ct.*		*Lbs.*	*Lbs.*	*1,000 lbs.*	*Lbs.*									
Douglas fir.....	8 x 16..	45	31.5	27.2	6.8	36	0	3	6,930	3,520	1,425	295	6	1	3	1	17	10	.....	C. S.....	Due to large corner knot at center of top edge.
		46	35.4	28.3	12.4	35	0	3	6,900	4,100	1,590	292	....	....	....	....	7	1	.....	C.....	No apparent cause.
		47	34.6	28.3	8.6	32	0	1	6,850	4,390	1,560	290	....	....	....	....	6	....	.....	C. T....	Do.
		48	32.6	30.6	13.0	35	0	3	6,850	4,100	1,900	290	....	....	5	....	20	2	.....	C. S.....	Due to large knot 3 inches from center on top face.
		49	32.5	27.9	15.0	.....	0	1	6,840	4,220	1,760	289	....	....	2	....	2	....	.....	C. S.....	No apparent cause.
		50	29.1	31.9	16.3	39	0	1	6,800	4,570	1,915	290	....	....	....	....	9	....	.....	C. S.....	Do.
		51	30.3	28.9	5.4	34	0	3	6,780	5,860	1,580	287	3	2	1	2	15	8	.....	C. T....	Large knot on upper face 9 inches from center.
		52	36.4	31.0	7.0	39	0	1	6,730	.....	1,780	286	2	....	....	....	13	1	.....	C. T....	No apparent cause.
		53	30.6	30.3	13.7	30	0	1	6,720	4,650	1,630	285	1	1	2	....	8	1	.....	T. C....	Large corner knot 12 inches from center.
		54	33.0	27.0	13.0	.....	0	1	6,680	3,850	1,604	282	....	1	3	....	9	1	.....	C. T....	No apparent cause.
		55	30.5	32.6	8.0	.....	0	1	6,680	4,690	1,792	283	....	2	....	....	7	7	.....	T. S.....	Do.
		56	32.7	30.5	6.9	39	0	3	6,670	4,640	1,715	283	2	1	7	....	12	3	Pitch streak...	C. T....	Small knot on top face 2 inches from center.
		57	27.0	28.1	9.8	29	4	1	6,640	4,420	1,380	281	....	....	1	1	8	4	Pitch streaks..	C. T....	No apparent cause.
		58	29.6	31.9	21.5	38	0	1	6,610	4,420	1,765	281	1	....	2	3	12	6	.....	C. S.....	Large knot on top face 11 inches from center.
		59	32.8	28.8	10.0	41	0	1	6,600	4,090	1,605	279	....	....	....	....	7	....	Pitch seam....	C. T....	No apparent cause.
		60	30.5	30.4	9.1	30	0	1	6,600	4,420	1,750	279	....	....	2	....	8	....	.....	C.....	Small knot on top face 13 inches from center.
		61	26.9	29.7	17.8	31	0	1	6,580	4,600	1,755	280	....	....	....	....	5	....	.....	C. S.....	No apparent cause.
		62	32.6	27.4	13.0	.....	0	1	6,580	4,085	1,580	276	2	....	2	4	2	7	Pitch pocket..	C. T....	Do.
		63	33.6	25.7	6.1	27	0	3	6,570	3,740	1,410	279	....	....	2	1	4	2	.....	C. T....	Large corner knot 3 inches from center.
		64	32.5	27.4	13.0	.....	0	1	6,570	3,806	1,422	278	....	....	3	....	12	13	Pitch pocket..	C. S.....	Small knot on top face near center.
		65	29.2	29.6	10.3	32	0	3	6,560	4,390	1,560	278	3	....	3	1	15	7	Pitch seam....	C. T....	Small knot on top face 9 inches from center.
		66	29.4	28.3	7.9	33	0	1	6,550	3,950	1,730	276	....	....	2	....	3	....	.....	C. S.....	No apparent cause.
		67	32.6	26.4	10.0	.....	4	1	6,540	3,485	1,577	277	....	1	....	1	13	5	.....	C. T....	Do.
		68	29.9	28.6	7.6	27	0	1	6,540	4,110	1,590	277	....	2	2	3	10	3	.....	T. C....	Large knot 4 inches from center on lower edge.

69	32.7	27.4	6.9	27	0	3	6,500	4,360	1,487	276	....	1	2	3	13	5	.....	C. T....	No apparent cause.
70	35.9	28.8	15.0	37	5	1	6,490	3,750	1,520	276	2	....	....	....	7	1	.....	C. T....	Do.
71	30.1	30.0	6.9	40	0	3	6,470	4,330	1,660	273	3	1	2	1	7	8	.....	C. T....	Do.
72	26.4	33.1	20.2	45	10	1	6,440	4,360	2,070	274	1	....	....	....	24	....	Checks.....	C. S....	Do.
73	26.5	27.1	7.2	35	0	3	6,440	4,120	1,518	273	4	1	4	....	11	....	.....	C. T. S..	Do.
74	32.8	25.7	23.3	30	0	1	6,420	3,760	1,425	273	....	....	1	....	11	6	Pitch pockets.	C. T....	Do.
75	34.2	27.8	8.0	.....	0	4	6,420	4,060	1,751	276	....	....	3	....	13	6	.....	C. T....	Do.
76	29.4	29.3	12.5	34	8	1	6,360	3,540	1,500	269	....	....	3	....	17	12	.....	C. S....	Do.
77	33.5	26.9	10.8	30	0	1	6,320	4,120	1,600	273	2	....	....	....	7	....	.....	C. T....	Do.
78	32.1	29.0	9.6	30	0	3	6,320	4,970	1,690	268	3	....	4	....	11	6	.....	C. T....	Do.
79	35.0	.....	15.1	57	0	1	6,320	4,190	1,807	423	....	....	....	....	....	....	.....	C. S....	Do.
80	32.3	31.3	7.1	30	0	3	6,310	4,690	2,000	260	....	....	5	....	16	1	.....	C. T....	Small corner knot 6 inches from center.
81	32.8	27.2	14.2	40	60	3	6,310	3,550	1,675	267	2	....	....	....	16	3	.....	C. T....	No apparent cause.
82	38.5	28.2	9.3	47	0	1	6,300	4,230	1,744	426	....	....	1	3	2	1	.....	C. S....	Do.
83	33.7	29.8	13.7	34	0	1	6,280	4,040	1,640	266	....	....	7	....	3	3	.....	C.....	Do.
84	31.6	27.4	19.5	34	0	1	6,260	4,400	1,695	279	....	....	....	....	10	1	.....	C. T....	Do.
85	32.1	28.0	10.2	37	0	4	6,250	4,110	1,345	265	....	....	3	1	2	3	.....	C. T....	Small knot at center of top face.
86	27.3	27.1	15.5	38	0	3	6,220	4,630	1,425	254	2	2	....	1	22	4	Pitch pocket..	T. C. S..	Large corner knot 5 inches from center.
87	35.1	25.7	8.8	24	0	3	6,210	3,810	1,465	263	....	....	2	....	4	2	.....	C. T....	Small knot on top face 3 inches from center.
88	31.7	27.9	5.2	39	0	3	6,190	3,500	1,755	263	4	....	4	1	22	1	.....	T. C....	Small corner knot 9 inches from center.
89	32.7	26.6	7.1	27	0	1	6,190	4,100	1,530	263	3	....	1	2	10	4	.....	C. T....	No apparent cause.
90	32.7	27.9	15.8	45	0	3	6,190	3,980	1,722	415	2	....	1	2	16	9	.....	C. T....	Large knot 27 inches from center.
91	34.3	26.3	8.1	28	0	4	6,180	4,080	1,505	263	1	1	....	2	10	3	.....	C. T....	No apparent cause.
92	36.0	30.2	10.9	52	0	1	6,170	4,510	1,777	409	....	....	....	....	....	....	.....	C. T....	Do.
93	35.5	27.2	7.8	29	0	4	6,130	3,480	1,510	262	2	1	3	4	14	5	.....	C. T....	Do.
94	29.6	29.0	10.9	32	0	1	6,120	4,610	1,560	259	5	1	2	1	8	....	.....	C. T....	Do.
95	31.2	29.6	9.1	30	0	3	6,090	4,980	1,645	258	....	....	3	....	1	1	Pitch seam....	C. S....	Do.
96	28.1	29.2	11.8	26	0	4	6,080	4,050	1,520	259	5	....	....	....	10	13	.....	C. T....	Do.
97	30.3	31.8	10.4	33	0	1	6,050	4,050	1,750	264	1	1	1	....	15	2	.....	T.....	Large spike knot 43 inches from center.
98	30.1	29.9	9.2	34	0	1	6,030	3,810	1,510	256	1	....	5	....	4	....	.....	C. T....	Small knot on top face 3 inches from center.
99	31.4	28.7	17.0	32	0	1	6,030	3,780	1,405	256	2	1	....	....	12	6	.....	C. T....	No apparent cause.
100	35.5	25.7	6.8	30	0	1	5,970	3,860	1,390	252	4	1	4	....	13	2	.....	C. T....	Do.
101	33.5	26.4	7.2	40	0	1	5,970	3,110	1,470	261	3	....	11	....	12	....	.....	C. T....	Do.
102	32.0	28.1	14.0	.....	.....	1	5,950	4,060	1,472	252	3	....	....	2	5	4	.....	C. T....	Do.
103	28.6	29.9	8.5	37	.....	3	5,930	4,630	1,610	252	6	3	2	....	35	9	.....	C. T....	Small knot on top face 5 inches from center.
104	33.9	28.4	6.2	34	0	4	5,890	4,391	1,485	250	7	1	2	....	13	2	.....	C. T....	No apparent cause.
105	29.5	30.7	11.0	.....	0	3	5,885	3,822	1,712	248	1	1	3	1	12	5	.....	C. S....	Small corner knot 12 inches from center.
106	32.0	26.2	12.0	44	.....	3	5,870	4,040	1,700	391	2	....	3	....	28	....	.....	C. T....	Small knot on top face.
107	30.4	25.8	7.6	37	.....	3	5,860	4,300	1,600	391	1	....	2	....	24	2	.....	C. T. S..	No apparent cause.
108	32.6	27.2	14.0	.....	0	1	5,850	3,800	1,438	247	2	4	4	1	4	7	.....	C. T....	Large knot on top face 2 inches from center.
109	34.0	25.6	6.0	40	0	1	5,830	4,120	1,388	251	2	....	3	2	19	8	.....	T. S....	No apparent cause.

TABLE 14.—*Data on individual bending tests of green timbers of commercial sizes*—Continued.

Species.	Size.	Reference number.	Moisture.	Dry weight per cubic foot.	Rings per inch.	Summer wood.	Sap.	Cross-section classification.	Modulus of rupture per square inch.	Fiber stress at elastic limit per square inch.	Modulus of elasticity per square inch.	Horizontal shear per square inch.	Number of knots.						Other defects.	Manner of failure.	Cause of first failure.
													Vol. I.		Vol. II.		Vol. III.				
													Less than 1½ inches.	1½ inches and over.	Less than 1½ inches.	1½ inches and over.	Less than 1½ inches.	1½ inches and over.			
	Inches.		*P. ct.*	*Lbs.*		*P. ct.*	*P. ct.*		*Lbs.*	*Lbs.*	*1,000 lbs.*	*Lbs.*									
Douglas fir	8 x 16	110	26.6	30.5	6.2	35	.....	4	5,820	4,370	1,650	247	9	1	3	....	17	5	.....	T. C....	Irregular grain caused by small knot at center of bottom face.
		111	33.0	25.1	8.6	42	.....	1	5,820	3,700	1,534	391	....	....	1	2	11	2	.....	C. T. S..	Due to knot on top face.
		112	35.2	29.1	5.6	32	20	2	5,780	4,360	1,515	246	4	....	1	....	18	2	.....	C. T....	No apparent cause.
		113	35.1	26.9	8.0	33	0	3	5,770	4,420	1,645	244	3	2	1	....	8	....	.....	C. T....	Small knot on top face 1 inch from center.
		114	36.9	25.2	8.9	38	10	1	5,770	3,230	1,240	244	....	....	1	....	14	1	.....	C. T....	No apparent cause.
		115	32.0	28.2	7.3	37	0	1	5,740	4,070	1,441	388	1	2	2	1	1	7	.....	T.....	Large corner knot 22 inches from center.
		116	32.3	30.1	10.1	31	0	3	5,720	5,390	1,995	240	1	....	1	4	5	4	Checks.....	T.....	Irregular grain caused by large knot 13 inches from center.
		117	27.7	27.1	19.0	.....	.....	1	5,660	3,780	1,330	239	2	....	....	....	2	....	.....	C. T....	No apparent cause.
		118	36.8	26.8	7.0	26	0	4	5,660	3,200	1,550	241	....	1	3	....	13	8	.....	C. T....	Do.
		119	26.3	26.7	9.2	28	0	1	5,630	4,090	1,385	235	2	1	2	5	5	8	.....	C. T....	Do.
		120	33.7	27.1	14.6	36	0	3	5,580	3,420	1,468	389	....	....	2	....	6	4	.....	C. T. S..	Do.
		121	31.8	27.1	7.6	32	0	1	5,570	3,190	1,410	236	....	2	4	3	9	6	.....	C. S.....	Small corner knot at center.
		122	34.2	26.0	12.0	.....	.....	1	5,570	3,790	1,457	236	1	....	....	....	10	3	.....	C. T. S..	No apparent cause.
		123	33.2	.....	17.7	40	0	1	5,550	3,440	1,480	365	....	....	....	....	....	....	.....	C. T....	Do.
		124	32.0	29.5	8.5	28	0	1	5,550	4,690	1,465	235	....	....	2	2	6	4	Pitch pocket..	C. S.....	Do.
		125	32.4	25.7	14.0	.....	0	1	5,515	3,790	1,324	233	....	....	....	1	21	3	.....	T. C....	Due to cross grain and checks.
		126	27.9	28.8	7.8	30	0	3	5,510	3,240	1,300	233	2	2	3	4	9	12	.....	T. C....	Large corner knot 22 inches from center.
		127	31.2	26.9	8.0	.....	0	1	5,490	3,260	1,545	232	1	1	1	5	21	8	.....	C. S.....	Large knot at center of top face.
		128	35.1	25.9	9.0	.....	0	4	5,490	3,200	1,398	232	1	4	....	....	12	2	.....	C. T....	Small knot on top face 2 inches from center.
		129	32.1	30.2	10.5	37	0	1	5,460	4,110	1,520	231	2	....	....	....	4	....	.....	T. C....	Small corner knot at center.
		130	35.4	27.3	6.4	44	.....	3	5,460	4,340	1,483	365	4	2	3	1	18	6	.....	T.....	Irregular grain due to knot.

131	32.1	26.1	8.3	35	0	3	5,460	3,720	1,505	367	....	....	....	....	....	....	.....	C. T....	No apparent cause.
132	29.5	27.3	10.4	32	.....	1	5,450	3,518	1,370	231	....	2	....	4	4	11	.....	T. C. T..	Large corner knot 15 inches from center.
133	27.7	28.2	13.7	38	0	1	5,440	4,080	1,505	232	....	3	2	1	6	1	.....	T. C. S..	Large corner knot at center.
134	29.5	27.7	6.5	29	0	3	5,430	3,810	1,305	230	....	....	2	3	11	8	.....	C. T....	Large knot on top face 3 inches from center.
135	32.3	30.0	11.5	39	0	1	5,370	3,570	1,430	226	2	....	....	....	7	6	.....	T.....	Irregular grain due to knot 28 inches from center.
136	31.9	26.2	8.0	.....	0	1	5,350	4,065	1,478	226	3	1	5	....	14	7	.....	C. T....	Small knot at center of top face.
137	32.8	24.1	6.0	.....	.....	3	5,335	3,215	1,513	225	1	....	1	....	5	1	.....	C. T....	No apparent cause.
138	29.2	30.9	14.0	32	0	1	5,320	4,300	1,760	227	....	....	....	....	6	....	Pitch pocket..	C. T....	Do.
139	33.2	28.6	19.0	.....	.....	1	5,310	3,210	1,337	224	3	....	5	....	7	....	Several curls..	T. C....	Due to cross grain.
140	30.0	25.3	20.0	.....	.....	3	5,310	3,505	1,280	224	....	....	1	1	8	....	.....	T. C....	Do.
141	28.6	26.8	8.3	26	.....	3	5,310	3,500	1,360	225	....	1	3	5	17	10	.....	C. T....	Small knot on top face 3 inches from center.
142	33.7	28.3	13.0	.....	0	1	5,290	4,100	1,357	223	1	1	2	2	3	18	.....	T.....	Large knot on corner 25 inches from center.
143	27.9	25.3	17.0	.....	0	1	5,250	2,916	1,318	222	....	....	1	....	5	4	.....	C. T....	No apparent cause.
144	35.7	27.6	14.1	47	0	1	5,210	4,060	1,115	347	....	....	....	....	....	....	.....	T.....	Brash failure.
145	30.8	26.6	10.0	.....	.....	1	5,180	3,790	1,448	219	....	....	1	4	24	3	.....	C. T....	Small knot on top face 2 inches from center.
146	25.5	29.1	11.0	35	0	1	5,170	2,950	1,050	218	....	....	1	....	7	7	Crooked grain.	T.....	Irregular grain near center lower edge.
147	33.4	27.0	19.5	31	5	1	5,170	3,260	1,310	219	....	3	2	1	3	6	.....	T. C. T..	Large corner knot 24 inches from center.
148	28.3	27.0	7.8	32	0	1	5,170	3,320	1,600	218	....	....	1	....	11	1	.....	C. S....	No apparent cause.
149	27.5	28.6	15.5	40	3	1	5,170	3,830	1,280	219	1	....	2	....	1	1	.....	C. T. S..	Large knot on top face 4 inches from center.
150	29.0	26.3	7.0	.....	0	3	5,168	3,790	1,299	219	....	3	1	2	4	10	.....	T. C....	Large corner knot 16 inches from center.
151	29.9	26.5	20.8	29	0	1	5,110	2,950	1,230	216	1	....	....	3	2	4	.....	C. S....	Large knot on top face 25 inches from center.
152	30.8	30.5	6.1	36	0	1	5,080	4,110	1,170	215	....	2	2	3	5	12	Checks.....	T. C....	Irregular grain due to large knot 13 inches from center.
153	24.9	27.4	10.0	28	0	1	4,950	3,540	1,310	209	....	3	3	4	8	7	.....	C. T....	Small knot on top face 3 inches from center.
154	25.7	30.3	10.3	31	0	1	4,860	3,800	1,440	206	....	1	2	2	11	14	Pitch seams...	C. T....	No apparent cause.
155	36.1	27.1	16.3	31	60	4	4,860	3,490	1,340	247	7	2	4	....	15	2	.....	C. T....	Do.
156	31.3	25.4	9.7	26	0	3	4,830	2,920	1,120	204	1	2	4	7	17	11	.....	T. C. T..	Large knot on lower edge 3 inches from center.
157	32.2	24.4	5.0	32	0	3	4,810	2,930	1,450	203	3	....	4	2	18	4	.....	C. T....	Small knot on top face 8 inches from center.
158	30.5	25.8	7.0	.....	0	1	4,770	3,503	1,283	219	1	2	....	1	4	12	.....	T. C....	Large knot on bottom face 12 inches from center.
159	30.4	24.6	16.0	.....	0	3	4,760	3,760	1,148	202	2	1	2	3	6	2	.....	C. T....	No apparent cause.
160	30.4	25.4	4.8	33	0	3	4,700	3,250	1,210	199	2	4	2	5	24	11	.....	C. T....	Large knot on top face 1 inch from center.

TABLE 14.—*Data on individual bending tests of green timbers of commercial sizes*—Continued.

Species.	Size.	Reference number.	Moisture.	Dry weight per cubic foot.	Rings per inch.	Summer wood.	Sap.	Cross-section classification.	Modulus of rupture per square inch.	Fiber stress at elastic limit per square inch.	Modulus of elasticity per square inch.	Horizontal shear per square inch.	Number of knots.						Other defects.	Manner of failure.	Cause of first failure.
													Vol. I.		Vol. II.		Vol. III.				
													Less than 1½ inches.	1½ inches and over.	Less than 1½ inches.	1½ inches and over.	Less than 1½ inches.	1½ inches and over.			
	Inches.		*P. ct.*	*Lbs.*		*P. ct.*	*P. ct.*		*Lbs.*	*Lbs.*	*1,000 lbs.*	*Lbs.*									
Douglas fir.....	8 x 16..	161	31.3	27.9	10.0	.....	0	3	4,660	.....	1,180	197	2	1	....	2	3	9	.....	C. T.....	Large knot at center of top face.
		162	30.2	31.4	14.1	39	0	1	4,630	3,390	1,238	297	....	....	4	2	5	2	.....	C. T.....	Small knot on top face 2 inches from center.
		163	33.4	26.8	11.3	46	0	1	4,610	4,110	1,260	309	....	....	....	....	....	....	.....	T.....	Due to brash failure.
		164	33.8	28.3	6.9	47	.....	3	4,600	3,500	1,477	304	2	1	6	1	25	8	.....	T.....	Due to knot.
		165	25.6	29.8	12.9	33	0	1	4,570	2,650	1,180	194	....	2	....	5	7	11	.....	T. C. T..	Large knot and irregular grain center of lower edge.
		166	30.1	26.1	4.6	31	0	1	4,495	2,705	1,270	191	1	1	5	1	10	13	.....	T.....	Irregular grain due to large knot 11 inches from center.
		167	29.7	31.0	10.9	35	0	1	4,465	3,500	1,895	284	3	....	5	....	11	....	.....	C. T.....	No apparent cause.
		168	30.5	25.1	17.0	.....	0	1	4,460	3,495	1,332	189	....	....	2	1	4	....	.....	C. T. S..	Do.
		169	31.8	30.5	17.0	31	25	1	4,440	3,060	1,632	190	3	....	....	....	13	....	Pitch seams...	T.....	Due to cross grain.
		170	29.8	29.4	15.5	49	0	1	4,380	3,450	1,419	297	1	1	4	....	8	9	.....	T.....	Large knot on bottom face at center.
		171	33.6	25.5	6.9	41	.....	3	4,360	3,010	1,242	291	1	2	2	3	21	8	.....	T.....	Due to knot.
		172	33.0	27.9	17.0	.....	0	1	4,330	2,634	1,305	186	....	3	1	6	7	11	Cross grain....	T.....	Cross grain.
		173	34.4	28.4	5.5	28	0	1	4,230	3,390	1,300	184	2	1	5	1	14	3	.....	T.....	Irregular grain due to large spike knot 28 inches from center.
		174	31.9	28.1	12.0	.....	0	1	4,220	3,483	1,371	179	2	3	....	2	5	6	.....	T.....	Large knot through piece 6 inches from center on lower edge.
		175	28.2	22.0	18.0	.....	0	1	4,220	2,710	827	178	....	1	7	....	....	7	.....	T.....	Cross grain.
		176	33.5	29.3	7.9	39	0	3	4,160	3,230	1,410	177	1	....	1	1	9	3	Pitch seam....	S.....	Pitch pocket.
		177	36.9	24.4	4.7	36	.....	3	4,120	2,950	1,404	277	2	....	4	1	32	4	.....	C. T.....	No apparent cause.
		178	32.1	29.1	15.7	33	0	3	4,120	2,960	1,400	175	....	....	1	....	10	....	.....	S.....	Do.
		179	30.8	25.8	4.1	25	0	3	4,000	2,650	1,020	170	1	4	7	2	11	7	.....	C. T.....	Small knot through piece center of upper edge.
		180	32.7	28.1	9.4	30	8	1	3,910	3,300	1,305	168	3	2	....	....	10	11	.....	T.....	Irregular grain due to large spike knot 20 inches from center.

		181	32.9	27.2	8.5	32	0	3	3,900	2,640	1,270	165	2	2	....	5	14	5	Pitch pocket..	T. C. T..	Large knot on bottom face 24 inches from center.
		182	28.1	27.6	17.7	31	2	1	3,660	2,950	1,135	155	....	8	2	4	1	8	.....	T.....	Large corner knot 8 inches from center.
		183	29.8	22.6	15.0	.....	0	1	3,640	2,330	890	154	....	2	1	....	2	3	.....	T.....	Cross grain.
		184	31.8	25.5	15.0	.....	0	1	3,560	2,424	1,352	146	....	1	....	1	7	7	.....	T. C....	Irregular grain for 51 inches from center.
		185	26.8	28.1	6.3	31	0	1	3,498	2,668	1,300	148	1	3	....	3	5	10	.....	T.....	Large knot on lower edge 25 inches from center.
		186	31.7	24.6	7.0	.....	0	3	3,481	2,910	1,363	147	1	1	....	2	18	4	.....	S.....	No apparent cause.
		187	28.5	31.0	9.1	29	5	1	3,460	2,920	1,080	147	2	4	1	4	2	22	.....	T.....	Large knot on lower edge near center.
		188	33.5	29.3	5.6	36	4	1	3,340	2,940	1,250	141	....	4	8	1	6	11	.....	T.....	Large corner knot at center.
		189	32.1	25.5	3.5	25	0	3	3,250	2,050	953	138	4	2	3	4	10	20	Pitch seams...	T.....	Small corner knot and large knot on lower face 13 inches from center.
		190	24.9	29.2	9.2	26	0	1	3,180	2,360	1,200	134	....	....	1	1	3	16	.....	T.....	Irregular grain due to large knot 5 inches from center.
		191	29.6	28.6	10.4	34	5	1	2,930	2,340	956	125	1	1	....	3	1	5	.....	T.....	Irregular grain due to large knot 6 inches from center.
Average.....	.....	.....	31.5	28.4	11.0	35	1	.....	5,983	3,968	1,517	269									
Douglas fir.....	5 x 8..	192	31.3	33.3	5.9	33	0	1	7,840	5,120	2,220	261	....	....	....	....	....	....	.....	C.....	No apparent cause.
		193	29.4	35.5	12.4	40	0	1	7,360	4,890	1,674	245	....	....	....	....	....	....	.....	T.....	Do.
		194	29.3	35.1	14.4	49	0	1	7,290	5,350	2,194	243	....	....	....	....	1	....	.....	C. T....	Do.
		195	29.0	32.1	15.7	49	0	1	7,270	4,790	1,767	242	....	....	....	....	....	....	Pitch pocket..	C.....	Do.
		196	33.1	32.0	20.5	39	0	1	7,180	4,500	2,146	239	....	....	....	....	....	....	.....	C.....	Do.
		197	31.0	30.8	7.4	51	0	1	6,850	4,890	1,789	228	....	....	....	....	....	....	.....	C.....	Do.
		198	27.6	33.3	21.1	42	0	1	6,810	5,370	1,813	227	....	....	....	....	2	....	.....	C. T....	Do.
		199	29.0	30.3	5.6	36	0	1	6,800	4,730	1,855	218	4	1	....	....	3	3	.....	C. T....	Large knot on top face 10 inches from center.
		200	32.0	28.4	23.0	40	0	1	6,780	4,560	1,641	225	....	....	....	....	....	....	.....	C.....	No apparent cause.
		201	27.6	32.1	11.0	51	0	1	6,660	4,510	1,801	221	....	....	....	1	3	3	.....	C. T....	Large knot on top face 45 inches from center.
		202	31.2	31.1	19.0	47	0	1	6,650	3,650	1,654	222	....	....	....	....	....	....	.....	C. T....	No apparent cause.
		203	29.6	27.3	12.3	38	0	4	6,580	4,770	1,765	220	....	....	3	2	9	3	.....	C. T....	Large loose knot on upper edge 21 inches from center.
		204	30.6	30.8	16.9	44	0	1	6,560	4,870	1,822	218	....	....	....	....	....	....	.....	C.....	No apparent cause.
		205	29.9	29.4	21.2	41	0	1	6,480	4,530	1,841	216	....	....	2	....	8	....	.....	C. T....	Small knot on top face 9 inches from center.
		206	28.5	31.3	15.0	46	0	4	6,420	3,660	1,878	214	....	....	....	....	5	3	.....	C. T....	No apparent cause.
		207	28.9	30.0	13.4	62	0	1	6,200	4,540	1,744	205	....	....	....	....	....	....	.....	C.....	Do.
		208	29.4	27.4	10.6	37	0	4	6,020	3,660	1,592	201	....	....	4	....	7	....	.....	C. T....	Do.
		209	28.1	30.6	12.2	39	0	4	5,990	3,680	1,648	199	....	....	....	....	2	7	.....	C. T....	Do.
		210	25.7	28.3	15.0	39	0	1	5,980	4,320	1,718	199	....	....	....	2	2	....	.....	C.....	Large corner knot 26 inches from center.

TABLE 14.—*Data on individual bending tests of green timbers of commercial sizes*—Continued.

Species.	Size.	Reference number.	Moisture.	Dry weight per cubic foot.	Rings per inch.	Summer wood.	Sap.	Cross-section classification.	Modulus of rupture per square inch.	Fiber stress at elastic limit per square inch.	Modulus of elasticity per square inch.	Horizontal shear per square inch.	Number of knots.						Other defects.	Manner of failure.	Cause of first failure.
													Vol. I.		Vol. II.		Vol. III.				
													Less than 1½ inches.	1½ inches and over.	Less than 1½ inches.	1½ inches and over.	Less than 1½ inches.	1½ inches and over.			
	Inches.		*P. ct.*	*Lbs.*		*P. ct.*	*P. ct.*		*Lbs.*	*Lbs.*	*1,000 lbs.*	*Lbs.*									
Douglas fir	5 x 8..	211	29.0	27.9	9.3	47	0	1	5,950	4,920	1,841	196	....	....	....	....	....	....		C. T.	No apparent cause.
		212	28.7	25.4	19.4	40	0	1	5,950	4,800	1,568	198	....	....	....	....	....	....		C. T.	Do.
		213	25.9	28.6	12.9	34	0	1	5,920	5,090	1,660	197	....	....	1	1	....	....		C. T.	Small knot on top face 10 inches from center.
		214	35.3	30.8	8.7	39	0	1	5,870	3,920	1,923	195	....	....	....	....	1	5		C. T.	No apparent cause.
		215	29.4	27.5	22.2	41	0	1	5,760	3,180	1,355	190	....	....	1	2	4	2		C. T.	Large knot on top face 25 inches from center.
		216	33.8	28.7	17.1	36	0	1	5,720	3,370	1,613	191	....	....	2	....	1	....		C. T.	Loose knot through upper edge 10 inches from center.
		217	30.5	31.0	9.0	62	0	2	5,640	4,290	1,795	186	1	....	1	1	2	....		C. T.	No apparent cause.
		218	28.3	29.3	12.6	36	0	2	5,630	4,480	1,769	188	1	....	2	....	1	2		C. T.	Large loose corner knot 10 inches from center.
		219	25.6	28.2	4.7	39	0	3	5,570	3,990	1,865	185	3	....	2	....	4	1		C. T.	Small knot on top face 12 inches from center.
		220	30.9	28.6	6.1	32	0	4	5,560	3,410	1,555	185	5	....	5	....	7	....		C.	Small corner knot 27 inches from center.
		221	28.4	28.8	14.2	35	0	1	5,560	4,780	1,763	185	....	....	1	....	5	1		C. T.	Small knot at center of top face.
		222	27.0	29.0	9.5	54	0	3	5,550	4,870	1,600	183	....	....	....	....	5	12		C. T.	No apparent cause.
		223	28.9	27.0	13.9	40	0	1	5,540	4,500	1,538	185	....	....	....	....	7	1		C. T.	Do.
		224	29.6	27.4	27.0	44	0	1	5,520	3,670	1,255	184	....	....	....	....	1	....		C. T.	Do.
		225	28.5	29.0	16.1	34	0	1	5,410	3,740	1,599	180	....	....	2	2	....	4		C. T.	Large corner knot 14 inches from center.
		226	28.2	27.5	13.5	37	0	1	5,400	4,260	1,748	180	....	....	2	....	4	....		C. T.	No apparent cause.
		227	28.3	28.4	8.7	33	0	2	5,400	3,720	1,527	180	....	....	4	1	2	2		C. T.	Do.
		228	28.3	25.6	8.4	32	0	4	5,330	3,370	1,510	178	....	....	....	....	5	4		C. T.	Do.
		229	30.2	29.4	6.9	36	0	4	5,290	3,400	1,594	176	....	....	....	....	5	1		C.	Do.
		230	29.2	28.5	8.0	35	0	1	5,130	3,980	1,290	171	1	....	2	1	1	1		C. T.	Large knot at top face 9 inches from center.
		231	30.3	29.3	6.1	37	0	4	5,120	2,930	1,442	168	....	....	....	....	2	4		C. T.	No apparent cause.
		232	32.5	25.9	5.2	34	0	4	5,090	3,470	1,312	168	....	....	....	....	6	2		C. T.	Do.
		233	30.5	29.1	9.5	34	0	1	5,080	3,680	1,358	169	3	2	....	2	4	7		C. T.	Large corner knot 8 inches from center.

234	27.2	28.0	9.2	43	0	1	5,080	3,690	1,610	169	....	1	....	....	2	5	.....	C. T.....	No apparent cause.
235	27.5	28.8	13.3	56	0	1	5,010	4,020	1,653	165	....	3	....	....	3	....	.....	C. T.....	Large knot across top face 22 inches from center.
236	28.5	27.7	7.0	33	0	1	5,010	3,400	1,550	167	....	....	....	....	13	2	.....	C. T.....	No apparent cause.
237	30.9	28.6	9.8	32	0	1	4,990	3,690	1,450	166	....	....	....	1	4	2	.....	C. T.....	Do.
238	30.9	25.9	7.0	31	0	2	4,920	3,670	1,525	164	5	....	1	....	4	....	.....	C. T.....	Do.
239	33.1	27.8	8.8	32	0	2	4,840	3,090	1,547	161	....	....	6	....	2	....	.....	C.....	2 small knots on top face 5 inches from center.
240	44.6	26.4	13.0	35	10	2	4,830	3,100	1,407	160	1	....	3	....	....	....	.....	C. T.....	Large knot on top face 9 inches from center.
241	29.6	27.8	20.6	45	0	1	4,810	3,680	1,124	160	1	....	....	....	....	....	.....	T.....	Cross grain.
242	31.7	28.7	5.4	35	0	1	4,690	3,440	1,304	156	....	....	2	....	3	8	Cross grain....	T.....	Cross grain.
243	28.8	29.1	20.5	51	0	1	4,680	3,200	1,269	154	....	....	3	2	3	7	.....	C. T.....	Large knot across top face 20 inches from center.
244	32.8	27.8	4.6	27	0	3	4,660	3,370	1,300	156	....	....	....	3	....	8	.....	T.....	Irregular grain.
245	28.0	28.7	11.5	38	0	1	4,650	4,530	1,457	155	....	....	1	1	1	6	Cross grain....	T.....	Cross grain.
246	29.8	28.1	12.6	34	0	1	4,640	4,220	1,637	155	....	....	....	....	3	1	.....	T.....	Do.
247	28.1	27.1	8.4	32	0	3	4,620	2,550	1,242	154	....	....	2	3	7	4	.....	C. T.....	No apparent cause.
248	27.4	27.5	8.6	34	0	3	4,610	3,650	1,495	154	3	1	6	1	12	7	.....	C. T.....	Small knot on top face 25 inches from center.
249	31.9	26.4	8.4	42	0	2	4,600	2,570	1,510	152	....	....	....	....	2	5	.....	C. T.....	No apparent cause.
250	28.8	24.9	7.4	29	0	3	4,550	3,430	1,390	151	5	2	4	2	3	3	.....	C. T.....	Do.
251	29.1	24.8	6.8	29	0	3	4,520	3,140	1,478	150	....	3	2	3	3	3	.....	C. T.....	Small knot on top face 12 inches from center.
252	29.6	26.8	5.8	33	0	3	4,510	2,840	1,271	150	....	....	2	....	10	....	.....	C. T.....	No apparent cause.
253	28.2	27.6	9.9	44	0	1	4,480	3,400	1,395	149	....	3	3	3	7	4	.....	T. C.....	Cross grain.
254	27.9	27.8	9.4	34	0	1	4,430	3,370	1,575	148	....	....	....	....	8	3	.....	T. C.....	Do.
255	32.5	27.6	4.9	32	0	4	4,380	3,090	1,310	147	....	....	2	3	1	4	.....	T.....	Irregular grain.
256	30.7	26.8	9.6	57	0	1	4,380	3,400	1,468	145	....	....	....	....	2	5	Cross grain....	T.....	Cross grain.
257	32.5	25.8	6.4	49	0	1	4,310	3,380	1,525	143	....	....	....	....	7	3	.....	C. T.....	No apparent cause.
258	31.7	23.8	4.8	33	0	3	4,260	2,810	1,210	142	1	1	7	....	5	2	.....	C. T.....	Small corner knot 12 inches from center.
259	32.2	27.7	11.3	45	0	2	4,250	3,120	1,489	141	1	4	1	1	1	....	.....	T. C.....	Irregular grain due to large knots.
260	27.6	30.6	8.5	52	0	1	4,250	2,870	1,625	140	1	4	....	....	2	3	.....	T. C.....	Small knot across bottom face 20 inches from center.
261	31.2	24.9	6.5	26	0	3	4,220	2,850	1,350	140	3	1	7	....	5	....	.....	C. T.....	2 small knots on top face 29 inches from center.
262	27.2	29.0	14.7	39	0	1	4,100	3,950	1,308	137	....	....	....	....	1	10	Cross grain....	T.....	Cross grain.
263	38.2	26.6	5.6	38	0	2	4,030	2,810	1,312	134	....	....	....	....	2	6	.....	T. C.....	No apparent cause; brash failure.
264	29.5	24.7	12.2	47	0	1	3,990	2,850	1,280	132	2	....	....	....	11	1	Cross grain....	T.....	Cross grain.
265	29.5	24.2	3.7	20	0	3	3,970	2,280	1,140	132	....	2	6	1	10	6	.....	C. T.....	Small knot near top edge 7 inches from center.
266	28.0	26.9	7.0	37	0	4	3,910	3,460	1,267	130	5	1	3	....	5	7	.....	T.....	Irregular grain.
267	31.5	28.1	5.2	32	0	4	3,830	2,830	1,285	127	....	....	....	4	3	1	.....	C. T.....	Large corner knot 10 inches from center.
268	30.0	26.5	4.3	40	0	3	3,800	2,790	1,236	127	....	....	2	1	....	4	.....	C. T.....	Large knot on top face 8 inches from center.

TABLE 14.—*Data on individual bending tests of green timbers of commercial sizes*—Continued.

Species.	Size.	Reference number.	Moisture.	Dry weight per cubic foot.	Rings per inch.	Summer wood.	Sap.	Cross-section classification.	Modulus of rupture per square inch.	Fiber stress at elastic limit per square inch.	Modulus of elasticity per square inch.	Horizontal shear per square inch.	Number of knots.						Other defects.	Manner of failure.	Cause of first failure.
													Vol. I.		Vol. II.		Vol. III.				
													Less than 1½ inches.	1½ inches and over.	Less than 1½ inches.	1½ inches and over.	Less than 1½ inches.	1½ inches and over.			
	Inches.		*P. ct.*	*Lbs.*		*P. ct.*	*P. ct.*		*Lbs.*	*Lbs.*	*1,000 lbs.*	*Lbs.*									
Douglas fir	5 x 8..	269	30.5	26.5	7.6	40	0	1	3,710	2,000	1,275	123	1	2	....	2	2	5	.....	C. T.	No apparent cause.
		270	29.7	27.4	6.3	32	0	1	3,630	2,600	1,445	120	....	3	....	2	2	1	.....	T.	Large knot across bottom face 5 inches from center.
		271	30.1	23.9	3.5	31	0	3	3,510	2,590	1,211	116	3	....	2	2	3	2	.....	C. T.	No apparent cause.
		272	25.4	27.2	4.9	38	0	1	3,270	2,300	1,124	108	....	....	....	....	....	6	Cross grain.	T.	Cross grain.
		273	29.5	28.2	16.6	37	0	3	3,210	3,210	1,410	107	1	4	4	1	2	3	.....	T.	Irregular grain due to knots.
		274	40.1	27.1	4.0	38	0	1	3,090	2,530	1,111	103	2	2	....	3	....	5	.....	C. T.	Large knot at center of top edge.
		275	34.8	22.6	6.8	45	0	4	3,000	2,250	1,155	100	1	....	2	....	2	5	.....	C. T.	No apparent cause.
Average	.....	.....	30.1	28.2	10.8	39	0	.....	5,178	3,693	1,533	172									
Douglas fir	2 x 12..	276	26.9	28.5	26.8	57	0	1	7,350	5,200	1,912	355	....	....	....	....	....	....	.....	C. T.	Do.
		277	26.5	29.8	33.3	51	0	1	7,250	5,420	1,936	352	....	....	....	....	....	....	.....	C. T.	Do.
		278	26.1	27.6	34.4	53	0	1	7,030	4,500	1,834	340	2	....	....	....	5	....	Pitch pocket..	C. T.	Do.
		279	29.7	27.6	37.8	.....	0	1	6,490	4,130	1,608	315	....	....	....	....	....	....	.....	C. T.	Do.
		280	33.5	28.1	15.1	50	0	2	6,320	3,460	1,720	308	....	....	....	....	6	1	.....	C. T.	Do.
		281	29.1	27.3	35.6	.....	0	1	6,210	4,650	1,671	301	....	....	....	....	4	....	Pitch pocket..	C. T.	Pitch pocket on top face.
		282	33.3	27.8	21.3	63	0	1	6,120	4,570	1,701	297	....	....	1	....	1	....	.....	C. T.	No apparent cause.
		283	35.2	28.8	17.4	52	0	1	6,030	3,860	1,953	294	....	....	7	....	14	....	.....	C. T.	Do.
		284	33.0	26.8	16.6	56	0	1	5,830	3,930	1,865	283	....	....	7	....	9	2	.....	C.	Do.
		285	32.5	27.6	18.9	62	0	1	5,800	4,570	1,691	281	....	....	....	....	9	1	Pitch pockets.	C. T.	Do.
		286	30.0	26.3	32.3	49	0	1	5,650	4,230	1,566	274	....	....	2	....	1	....	.....do.....	C. T.	Do.
		287	28.0	26.4	26.4	55	0	1	5,640	3,810	1,558	275	....	....	....	....	1	....	.....do.....	C.	Do.
		288	30.4	25.6	43.1	.....	4	1	5,620	3,880	1,481	274	....	....	....	....	....	....	.....do.....	C. S.	Do.
		289	31.2	27.9	7.9	48	0	1	5,410	4,120	1,671	262	....	2	2	....	10	3	.....	C. T.	Do.
		290	43.1	27.2	6.6	44	0	2	5,310	4,090	1,605	259	6	....	1	1	23	3	.....	C. T.	Do.
		291	38.8	26.1	9.4	50	0	1	5,160	3,420	1,625	250	....	....	5	....	24	....	.....	C.	Do.
		292	42.2	26.9	6.0	39	0	4	4,860	3,240	1,431	236	12	....	1	1	23	3	.....	C. T.	Do.
		293	26.7	26.4	39.4	.....	1	1	4,860	2,970	1,639	235	....	....	....	....	9	....	.....	S.	Do.
		294	54.3	27.1	17.5	52	0	1	4,850	3,320	1,501	236	....	....	2	2	2	8	Pitch pocket..	C. T.	Do.

		295	47.1	27.9	11.4	50	0	4	4,550	3,270	1,763	220	9	....	....	....	25	2	.....	T. C.....	Small corner knot 21 inches from center.
		296	38.7	25.5	11.4	49	0	1	4,520	3,280	1,756	219	7	1	1	....	22	1	.....	C. T.....	No apparent cause.
		297	31.2	27.4	25.0	51	0	2	3,900	2,610	1,463	189	3	2	....	....	7	4	Pitch pockets..	T.....	Cross grain.
		298	35.3	27.7	15.4	38	0	2	3,680	2,940	1,364	179	3	2	....	....	7	6	.....	T.....	Small knot on lower face 44 inches from center.
		299	42.5	27.1	6.6	51	0	2	3,670	3,160	1,702	177	10	....	....	....	17	4	.....	T.....	Small corner knot 14 inches from center.
		300	48.3	28.5	6.3	41	0	4	3,660	2,620	1,393	177	17	....	1	....	17	3	.....	T. C.....	No apparent cause.
		301	51.8	27.5	13.6	50	0	2	3,490	2,630	1,469	168	6	....	1	....	6	1	Pitch pocket..	T.....	Irregular grain due to knots.
		302	39.3	27.4	13.3	45	0	2	3,180	2,600	1,448	154	....	....	2	2	1	5	.....	T.....	No apparent cause.
Average.....	.....	.....	35.7	27.4	20.3	50	0	.....	5,276	3,721	1,642	256									
Douglas fir.....	2 x 10..	303	29.0	26.9	43.3	.....	0	1	6,480	4,180	1,918	261	....	....	3	....	7	....	.....	C. T.....	Do.
		304	29.8	26.8	39.8	.....	0	1	5,850	4,240	1,807	234	....	....	....	....	3	1	Cross grain....	T. C.....	Irregular grain.
		305	30.3	25.9	18.8	49	0	2	5,640	3,900	1,719	227	....	1	2	....	3	3	.....	C. T.....	No apparent cause.
		306	29.4	27.4	30.0	45	0	1	5,500	3,280	1,918	221	7	....	1	....	7	....	.....	T. C.....	Irregular grain due to knot.
		307	33.0	26.5	20.6	49	0	1	5,420	3,100	1,551	217	....	....	....	....	....	....	Pitch pockets.	C. T.....	No apparent cause.
		308	30.8	24.5	52.4	.....	4	1	5,410	2,880	1,433	224	....	....	....	....	....	....	Pitch pocket..	C. T.....	Do.
		309	30.2	25.9	12.5	39	0	1	5,400	4,070	1,831	217	....	....	3	....	11	1	Check.....	C. T.....	Do.
		310	31.3	26.5	26.1	48	0	1	5,230	3,270	1,713	200	2	....	....	....	6	1	.....	C. T.....	Do.
		311	29.2	28.1	30.4	55	0	1	5,210	3,810	1,615	209	....	....	....	....	12	....	Crooked grain.	T. C. T..	Cross grain.
		312	33.7	26.0	21.1	43	0	1	5,140	2,970	1,764	207	6	1	....	....	7	....	.....	T. C.....	Spike knot across bottom face 10 inches from center.
		313	31.6	26.7	19.9	42	0	1	5,060	3,340	1,744	203	3	....	2	....	21	3	Cross grain....	T. C.....	Irregular grain due to knots.
		314	36.7	26.3	7.8	45	0	1	5,020	2,900	1,537	202	4	....	13	....	17	1	.....	C. T.....	Large knot on top face 2 inches from center.
		315	33.0	23.5	6.8	41	0	1	4,930	3,850	1,516	198	9	....	....	....	17	2	.....	C. T.....	No apparent cause.
		316	37.2	25.5	7.1	40	0	2	4,930	2,900	1,637	198	....	....	6	....	6	....	.....	C. T.....	Do.
		317	32.2	26.4	47.8	.....	0	1	4,800	2,960	1,520	199	....	....	....	....	....	....	Pitch pocket..	T.....	Cross grain.
		318	33.7	24.7	9.4	42	0	1	4,470	3,290	1,560	179	9	....	1	1	19	1	.....	C. T.....	Large knot near top edge 32 inches from center.
		319	31.8	27.0	24.9	39	0	2	4,460	3,290	1,544	179	10	....	2	....	7	1	.....	T. C.....	Small corner knot 22 inches from center.
		320	34.1	25.4	9.5	42	0	1	4,410	2,400	1,609	177	2	....	4	....	23	6	.....	C. T.....	No apparent cause.
		321	29.3	26.4	21.3	41	0	1	4,350	3,740	1,522	174	1	1	5	1	7	9	.....	T.....	Irregular grain.
		322	36.3	26.8	10.9	38	0	1	4,280	2,960	1,555	171	6	....	1	....	20	1	.....	T.....	Do.
		323	35.3	25.9	13.4	35	0	1	4,280	2,750	1,499	172	7	....	2	1	24	3	.....	T. C.....	Small corner knot 21 inches from center.
		324	43.3	25.4	7.9	40	0	1	4,150	2,990	1,514	166	1	....	5	2	14	1	.....	T. C.....	No apparent cause.
		325	39.4	23.7	5.0	35	0	4	3,650	2,640	1,297	146	17	....	3	....	26	4	Checks.....	T.....	Small corner knot 36 inches from center.

TABLE 14.—*Data on individual bending tests of green timbers of commercial sizes*—Continued.

Species.	Size.	Reference number.	Moisture.	Dry weight per cubic foot.	Rings per inch.	Summer wood.	Sap.	Cross-section classification.	Modulus of rupture per square inch.	Fiber stress at elastic limit per square inch.	Modulus of elasticity per square inch.	Horizontal shear per square inch.	Number of knots.						Other defects.	Manner of failure.	Cause of first failure.
													Vol. I.		Vol. II.		Vol. III.				
													Less than 1½ inches.	1½ inches and over.	Less than 1½ inches.	1½ inches and over.	Less than 1½ inches.	1½ inches and over.			
	Inches.		*P. ct.*	*Lbs.*		*P. ct.*	*P. ct.*		*Lbs.*	*Lbs.*	*1,000 lbs.*	*Lbs.*									
Douglas fir	2x10	326	30.5	26.7	35.3	48	3	1	3,270	2,770	1,553	131	3	1	....	....	11	2		T. C.	Irregular grain caused by knot.
		327	31.8	25.8	11.9	36	0	2	2,910	2,310	1,508	116	2	....	9	....	6	3		T.	Do.
		328	31.8	26.8	27.3	51	0	2	1,930	1,381	1,030	76	2	1	....	....	....	3		T. C.	Large corner knot 29 inches from center.
Average			32.9	26.1	21.6	43	0		4,699	3,160	1,593	189									
Douglas fir	2 x 8	329	35.2	28.5	23.0	50	0	1	7,810	4,390	2,100	249	....	....	3	....	2	....	Pitch pocket	C. T.	No apparent cause.
		330	33.0	31.4	19.3	57	0	2	7,320	4,200	1,859	234	....	....	....	....	....	2		C. T.	Do.
		331	38.5	30.1	12.4	46	0	1	6,820	4,650	1,882	226	....	....	3	....	4	....		C.	Do.
		332	35.4	29.1	28.5	49	0	2	6,720	4,240	1,833	213	....	....	....	....	3	....		C. T.	Do.
		333	29.8	27.3	37.8	47	0	1	6,520	4,370	1,904	208	....	....	3	....	1	....		C. T.	Do.
		334	28.1	27.4	36.6	50	0	2	6,520	3,700	1,890	208	....	....	....	....	2	....	Pitch pocket	C. T.	Do.
		335	34.6	30.1	10.1	49	0	2	6,470	4,180	1,812	213	5	....	2	....	4	....	do	C. T.	Small knot on top face, 36 inches from center.
		336	28.9	26.2	33.9	51	0	2	6,170	4,260	1,646	197	....	....	....	1	3	....	Pitch pockets.	C.	No apparent cause.
		337	33.0	26.3	18.5	46	0	2	6,170	3,710	1,979	197	....	....	4	....	5	....		C. T.	Small knot on corner, 6 inches from center.
		338	29.5	28.5	30.1	56	0	2	6,000	3,710	1,774	192	....	....	....	....	2	....	Pitch pocket	C. T.	No apparent cause.
		339	32.8	26.6	20.3	53	0	2	5,870	4,050	1,696	187	....	....	....	2	4	2		C. T.	Large knot near top edge, 40 inches from center.
		340	33.5	30.7	16.5	57	0	2	5,840	4,510	1,774	186	....	....	....	....	6	....	Pitch pockets.	C. T.	No apparent cause.
		341	43.5	25.8	12.4	49	0	2	5,280	3,420	1,899	168	....	....	6	....	6	1		C. T.	Small knot on top face at center.
		342	30.4	25.2	27.0	42	0	2	5,250	3,540	1,605	167	....	....	....	....	....	....	Pitch pocket	T.	No apparent cause—brash failure.
		343	33.2	23.8	11.9	40	0	2	5,210	3,320	1,522	165	....	....	....	....	4	1		T. C. T.	No apparent cause.
		344	33.6	23.9	14.9	44	0	2	4,960	2,980	1,503	158	....	....	....	....	7	1	Irregular grain.	C. T.	Do.
		345	40.3	26.1	8.0	42	0	2	4,920	3,790	1,506	156	1	....	10	....	13	....		C. T.	Small knot on top face, 20 inches from center.
		346	34.3	23.3	23.3	40	1	2	4,870	2,830	1,301	156	....	....	2	....	....	1		C. T.	No apparent cause.
		347	39.4	27.5	13.5	44	0	2	4,870	3,030	1,968	155	3	....	3	....	14	....		T. C.	Small corner knot, 14 inches from center.

		348	30.1	24.1	7.6	39	0	2	4,780	3,390	1,360	152				1	2	3	Cross grain	C. T.	No apparent cause.
		349	33.1	24.0	20.1	45	0	2	4,640	3,610	1,422	148					2			T.	No apparent cause—brash failure.
		350	33.2	23.7	10.0	39	0	1	4,560	3,660	1,333	145			2		2	1		C. T.	No apparent cause.
		351	33.0	24.0	12.8	41	0	2	4,530	2,080	1,333	144			3	3	2	2		C. T.	Large knot across top face, 4 inches from center.
		352	32.2	24.7	13.5	39	0	2	4,200	3,770	1,462	133	7	2	3	1	6	2		T.	Large spike knot on corner, 40 inches from center.
		353	31.7	23.9	7.8	37	0	2	4,140	3,140	1,165	132	6	1	2	1	7	4		C. T.	No apparent cause.
		354	35.8	23.6	8.4	42	0	2	3,950	3,050	1,342	126			1		2		Pitch pocket	C. T.	Do.
		355	31.4	24.6	6.3	40	0	1	3,940	3,430	1,268	125	2		1		12	4		T.	Cross grain.
		356	34.2	23.6	17.1	46	0	2	3,780	2,950	1,299	119		2	1	1			Pitch pocket	T.	Large corner knot, 43 inches from center.
		357	32.0	25.1	8.4	38	0	2	3,110	2,240	1,178	98	1	5	2		4	4		T.	Large knot across bottom face, 5 inches from center.
Average			33.6	26.2	17.6	45	0		5,352	3,593	1,607	171									
Douglas fir (fire killed).	8 x 16	1	33.7	27.0	12.6	48	0	1	6,050	3,800	1,560	400			5		7			C. T.	No apparent cause.
		2	33.0	25.0	16.8	45	0	1	5,810	3,780	1,574	384			6		6			C. T. S.	Do.
		3	33.5	29.2	9.8	44	0	3	5,710	3,830	1,595	377	3		7	4	9	17		C. S. T.	Do.
		4	38.0	26.0	15.6	48	0	1	5,660	4,230	1,548	373	1				18			C. S. T.	Do.
		5	36.7	27.2	11.6	48	0	1	5,650	4,250	1,599	372	1		1		18	2	Pitch pocket	C. S.	Do.
		6	33.0	25.5	16.8	52	0	1	5,600	3,350	1,544	370			5		8	1	do	C. T.	Do.
		7	36.1	26.8	16.9	48	0	4	5,570	3,990	1,552	368	1				5		Pitch pockets	C. T. S.	Do.
		8	35.5	28.5	9.0	38	0	3	5,550	3,120	1,731	366	12		7	3	31	12		C. T.	Large knot on top face, 28 inches from center.
		9	35.0	28.3	6.9	49	0	3	5,440	3,710	1,852	358	1	2	4	2	15	10		C. T.	No apparent cause.
		10	32.5	28.9	11.3	44	0	3	5,390	3,490	1,754	355			8	1	10	4		C. S.	Do.
		11	33.5	25.6	11.1	45	0	1	5,380	4,040	1,484	355	2		4	1	13	1		C. T. S.	Do.
		12	45.5	27.0	12.4	46	0	1	5,310	3,360	1,439	350	1	1	2	2	11	3		C. T.	Large corner knot, 5 inches from center.
		13	39.5	25.5	5.7	37	0	3	5,240	3,540	1,553	344	8		5	1	22	8		C. T.	Small knot on top face, 3 inches from center.
		14	34.0	29.0	10.0	44	0	3	5,230	4,050	1,652	344		1	4	6	19	10		C. T.	No apparent cause.
		15	38.9	26.4	10.4	37	0	3	5,190	3,860	1,712	340			7		31			C. T. S.	Small knot on top face at center.
		16	45.0	30.9	10.1	51	0	1	5,150	3,880	1,794	337			3		10	8		C. T. S.	No apparent cause.
		17	40.3	28.5	10.1	42	0	1	4,960	3,390	1,651	326	2	1	3		19	3		C. S.	Large knot on top face, 22 inches from center.
		18	33.6	29.3	11.8	38	0	1	4,960	3,640	1,594	326	17		5	1	41	3		C. T.	No apparent cause.
		19	33.6	25.3	11.5	40	0	1	4,820	3,490	1,539	317		2	3	2	7	5	Shake	T. C. S.	Irregular grain, caused by knot, 15 inches from center.
		20	32.4	25.6	10.8	43	0	3	4,780	3,620	1,376	314	7	1	3	3	28	16		C. T.	No apparent cause.
		21	44.0	23.6	6.9	30	0	4	4,570	3,520	1,311	301	8	1	1		21	2		T. C.	Small corner knot, 25 inches from center.
		22	33.0	21.6	8.9	43	0	3	4,520	2,720	1,426	297	2		5	3	8	6		C. T.	No apparent cause.
		23	29.6	25.1	16.4	47	0	1	4,460	3,620	1,413	293	1		5	1	20	3	Irregular grain	C. T. S.	Do.

TABLE 14.—*Data on individual bending tests of green timbers of commercial sizes*—Continued.

Species.	Size.	Reference number.	Moisture.	Dry weight per cubic foot.	Rings per inch.	Summer wood.	Sap.	Cross-section classification.	Modulus of rupture per square inch.	Fiber stress at elastic limit per square inch.	Modulus of elasticity per square inch.	Horizontal shear per square inch.	Number of knots. Vol. I. Less than 1½ inches.	Vol. I. 1½ inches and over.	Vol. II. Less than 1½ inches.	Vol. II. 1½ inches and over.	Vol. III. Less than 1½ inches.	Vol. III. 1½ inches and over.	Other defects.	Manner of failure.	Cause of first failure.
	Inches.		*P. ct.*	*Lbs.*		*P. ct.*	*P. ct.*		*Lbs.*	*Lbs.*	*1,000 lbs.*	*Lbs.*									
Douglas fir (fire killed.)	8 x 16..	24	37.1	25.8	7.0	46	0	3	4,320	3,140	1,458	285	5	....	1	3	16	6	.....	C. T. S..	Large knot on top face, 5 inches from center.
		25	30.5	24.9	12.7	42	0	1	4,240	3,110	1,289	322	5	....	.....	.....	18	1	.....	C. T.....	No apparent cause.
		26	33.6	25.0	11.4	44	0	1	4,230	2,910	1,467	277	4	4	2	1	8	7	.....	C. T. S..	Do.
		27	36.2	25.9	8.6	40	0	1	4,100	2,960	1,473	269	2	1	2	3	5	10	.....	C. T.....	Large knot on top face, 19 inches from center.
		28	58.0	24.6	6.4	42	0	3	4,100	3,610	1,333	269	13	2	.....	.....	18	1	.....	T.....	Irregular grain due to knots.
		29	38.9	26.4	9.1	47	0	1	4,080	2,670	1,321	269	2	....	8	2	17	8	.....	C. T.....	Small knot on top face at center.
		30	40.0	26.0	7.6	42	0	3	3,750	2,410	1,325	245	3	3	2	1	8	13	.....	T. C.....	Large knot on bottom face, 20 inches from center.
Average.....	.....	.....	36.8	26.5	10.9	44	0	.....	4,994	3 503	1 531	330									
Douglas fir.....	2 x 12..	31	31.2	29.2	12.1	49	0	1	6 560	4,290	1,930	319	.....	.....	2	....	13	3	.....	C.....	No apparent cause.
		32	30.9	31.4	22.0	59	0	1	6,540	4,960	1,803	317	.....	.....	.....	.....	5	2	Pitch pocket..	C.....	Do.
		33	33.4	28.8	14.0	69	0	1	6,450	4,060	2,011	314	.....	.....	3	....	4	....	.....	C.....	Do.
		34	33.1	27.0	14.5	49	0	1	6,420	4,420	1,858	312	.....	.....	.....	.....	.....	.....	Check.....	C. T.....	Do.
		35	29.3	26.5	13.5	51	0	1	6,360	4,280	1,859	308	.....	.....	.....	.....	1	....	Pitch pocket..	C. T.....	Do.
		36	32.8	29.5	15.5	58	0	1	6,310	3,890	2,058	307	.....	.....	2	....	16	2	.....	C.....	Do.
		37	28.3	27.4	23.4	60	0	1	6,270	4,560	1,916	305	.....	.....	.....	.....	.....	.....	.....	C. S.....	Do.
		38	35.3	28.8	26.0	58	0	1	6,030	4,550	1,775	293	.....	.....	.....	.....	.....	.....	Pitch pocket..	C.....	Do.
		39	28.1	27.6	36.8	.....	0	1	5,970	4,550	1,813	292	.....	.....	2	....	8	....	.....	C. T.....	Do.
		40	32.1	27.1	24.9	43	0	1	5,680	3,890	1,800	276	.....	.....	2	....	4	....	.....	C.....	Do.
		41	31.6	27.9	34.3	44	0	1	5,640	3,600	1,592	274	.....	.....	1	....	.....	.....	Pitch pocket..	C. S.....	Irregular grain, 14 inches from center.
		42	31.9	26.2	13.8	45	0	1	5,530	3,390	1,752	269	.....	.....	.....	.....	2	....	.....do.....	C. T.....	No apparent cause.
		43	35.3	26.6	12.8	42	0	1	5,300	3,740	1,688	258	.....	.....	8	....	16	....	.....	C. T.....	Do.
		44	32.2	26.8	9.9	44	.....	1	5,240	3,490	1,741	254	.....	.....	4	....	10	....	Pitch pocket..	C. T.....	Do.
		45	53.8	24.4	7.9	49	0	2	5,200	3,800	1,594	252	3	.....	.....	.....	4	1	Cross grain....	C. T.....	Do.
		46	30.3	25.2	19.8	55	0	1	5,160	4,130	1,533	248	2	....	5	....	4	1	.....	C. S.....	Do.

		47	37.0	26.7	10.3	52	0	1	5,150	3,580	1,693	250	1	....	5	....	8	4	.....	C.....	Small corner knot, 2 inches from center.
		48	59.7	24.6	10.9	50	0	1	5,140	3,000	1,585	249	....	....	4	....	17	....	.....	C. T.....	No apparent cause.
		49	33.0	26.0	32.3	51	0	1	5,130	3,360	1,544	249	....	....	2	....	2	....	Pitch pockets.	C.....	Irregular grain at third point.
		50	33.5	25.0	12.5	38	0	1	5,070	3,310	1,637	246	....	....	4	....	6	....	.....	C. T.....	No apparent cause.
		51	32.0	24.8	21.4	51	0	1	4,890	3,280	1,338	237	....	....	....	....	....	....	Cross grain....	C. T.....	Do.
		52	34.1	24.9	32.0	47	0	1	4,820	3,610	1,454	234	....	....	....	....	....	....	Pitch pockets.	C.....	Irregular grain 8 inches from center.
		53	35.3	25.5	7.0	41	0	1	4,700	2,940	1,526	228	4	....	5	....	24	2	.....	C. T.....	No apparent cause.
		54	28.5	24.1	23.1	52	0	1	4,530	4,040	1,301	219	....	....	....	....	....	....	Cross grain....	T.....	Cross grain.
		55	30.7	25.5	9.8	49	0	1	4,440	3,050	1,350	215	10	1	....	....	18	3	.....	T.....	Small corner knot at center.
		56	35.5	26.1	16.0	50	0	1	4,030	1,964	1,841	195	2	2	....	....	5	6	.....	T. C.....	Small knot on lower edge, 36 inches from center.
		57	.....	.....	10.7	36	0	4	3,880	2,920	1,147	188	11	....	....	....	10	5	.....	T.....	Small corner knot 32 inches from center.
		58	33.8	25.3	17.9	56	0	1	3,820	2,080	1,544	187	8	....	....	....	13	....	Pitch pockets.	T. C.....	Irregular grain.
		59	31.7	24.5	20.4	52	0	1	3,760	2,350	1,450	183	1	2	1	....	12	1	.....	T. C.....	Large corner knot 23 inches from center.
		60	41.2	24.6	7.5	44	0	1	3,640	2,930	1,281	176	9	....	....	....	21	5	.....	C. T.....	No apparent cause.
		61	35.9	25.0	9.0	51	0	2	2,750	1,980	1,193	132	8	....	....	1	14	7	.....	T.....	Irregular grain caused by knot.
		62	30.1	24.1	24.5	50	0	1	2,310	1,660	1,376	111	3	....	....	....	6	....	.....	T.....	Do.
Average.....	.....	.....	34.2	26.4	17.7	50	0	.....	5,085	3,489	1,624	247									
Douglas fir (fire killed).	2 x 10..	63	32.0	31.0	30.6	59	0	1	7,030	5,220	2,180	283	....	....	....	....	....	....	.....	C.....	No apparent cause.
		64	33.1	28.5	22.3	64	0	1	7,000	4,650	2,030	282	....	....	....	....	....	....	.....	C.....	Do.
		65	32.8	28.5	21.5	61	0	1	6,930	4,270	2,036	280	....	....	2	....	....	....	Pitch pocket..	C. T.....	Do.
		66	36.8	29.9	18.6	52	0	1	6,610	4,460	1,858	266	....	....	1	....	5	....	.....	C. T.....	Small corner knot at center.
		67	40.1	29.2	18.4	56	0	1	6,540	4,260	2,074	263	....	....	1	....	3	....	.....	C. T.....	No apparent cause.
		68	33.0	27.4	32.8	58	0	1	6,380	4,310	1,800	257	....	....	....	....	....	....	.....	C.....	Do.
		69	35.0	27.3	19.5	62	0	2	6,250	4,430	1,944	252	....	....	....	....	5	....	.....	C. T.....	Do.
		70	36.9	30.1	17.4	60	0	1	6,150	4,050	1,841	247	2	....	1	....	1	2	.....	C. T.....	Irregular grain 12 inches from center.
		71	37.4	30.3	16.5	55	0	2	6,110	4,560	1,729	246	....	....	2	....	6	5	Pitch pocket..	C. T.....	Small knot on top face, 12 inches from center.
		72	34.0	27.0	18.5	51	0	2	6,110	4,250	1,782	246	....	....	2	....	9	1	.....	C. T.....	No apparent cause.
		73	66.6	24.9	8.8	59	0	1	6,070	4,380	1,742	244	....	....	....	....	18	....	.....	C. T.....	Do.
		74	48.5	27.3	10.0	48	0	2	5,860	4,040	1,417	236	2	....	....	....	7	2	.....	C. T.....	Do.
		75	43.8	31.7	11.3	59	0	2	5,790	4,560	2,059	232	....	....	1	....	14	....	.....	C. T.....	Small corner knot 8 inches from center.
		76	47.3	26.6	14.4	50	0	2	5,750	3,900	1,577	231	....	....	3	....	4	....	Pitch Pocket .	C.....	Small corner knot 11 inches from center.
		77	36.9	26.3	14.6	58	0	1	5,670	4,320	1,861	228	....	....	....	....	4	1	.....	C.....	No apparent cause.
		78	36.0	27.0	23.0	57	0	1	5,520	4,280	1,675	222	....	....	....	....	5	....	Cross grain....	C. T.....	Do.
		79	42.4	29.8	15.4	56	0	1	5,510	3,980	2,017	221	....	....	3	....	6	1	.....	C.....	Do.
		80	34.2	25.8	26.0	57	0	2	5,480	3,920	1,577	221	....	....	5	....	4	....	.....	C. T.....	Do.
		81	32.9	25.4	29.3	56	0	1	5,180	3,550	1,634	209	2	1	1	....	8	1	.....	T. C.....	Large knot across lower face, 2 inches from center.

TABLE 14.—*Data on individual bending tests of green timbers of commercial sizes*—Continued.

Species.	Size.	Reference number.	Moisture.	Dry weight per cubic foot.	Rings per inch.	Summer wood.	Sap.	Cross-section classification.	Modulus of rupture per square inch.	Fiber stress at elastic limit per square inch.	Modulus of elasticity per square inch.	Horizontal shear per square inch.	Number of knots.						Other defects.	Manner of failure.	Cause of first failure.
													Vol. I.		Vol. II.		Vol. III.				
													Less than 1½ inches.	1½ inches and over.	Less than 1½ inches.	1½ inches and over.	Less than 1½ inches.	1½ inches and over.			
	Inches.		*P. ct.*	*Lbs.*		*P. ct.*	*P. ct.*		*Lbs.*	*Lbs.*	*1,000 lbs.*	*Lbs.*									
Douglas fir (fire killed.)	2x10..	82	38.0	26.5	13.5	58	0	1	5,140	3,890	1,782	207	....	....	3	....	5	....	.....	C. T.....	Small corner knot 21 inches from center.
		83	31.7	24.8	21.4	57	0	1	5,120	3,970	1,504	206	1	1	2	1	6	3	.....	C. T.....	No apparent cause.
		84	37.5	27.0	16.8	49	0	2	4,900	4,260	1,755	196	2	....	2	....	9	1	.....	T. C.....	Small knot on lower edge, 2 inches from center.
		85	33.2	27.9	19.0	59	0	1	4,800	3,300	1,778	193	1	....	2	....	5	....	Cross grain....	C. T.....	No apparent cause.
		86	36.3	25.1	14.1	53	0	1	4,750	4,040	1,665	191	2	....	3	....	7	2	.....	C. T.....	Small knot across top face, 19 inches from center.
		87	34.7	27.1	24.8	56	0	1	4,470	3,820	1,495	180	....	....	....	1	2	2	Pitch pocket..	C. T.....	No apparent cause.
		88	43.5	24.0	7.9	40	0	2	4,310	2,720	1,329	173	....	....	5	1	11	4	.....	C.....	Small knot on top face, 19 inches from center.
		89	41.0	26.3	6.3	48	0	2	4,210	2,910	1,520	169	9	....	....	....	11	2	Pitch pocket..	T.....	Irregular grain.
		90	46.2	27.0	6.5	51	0	2	4,030	2,680	1,340	165	2	....	12	....	17	3	Cross grain....	C. T.....	No apparent cause.
		91	48.5	28.5	10.4	57	0	1	3,710	3,060	1,677	148	5	1	....	....	16	1	.....	T. C.....	Small knot across bottom face, 29 inches from center.
		92	33.4	26.3	33.9	55	0	1	3,680	2,190	1,414	148	5	3	2	1	3	9	.....	T C.....	Small knot across bottom face, 15 inches from center.
		93	48.2	26.5	6.4	43	0	2	3,530	2,390	1,485	141	1	....	9	....	23	....	Pitch streak...	C. S.....	No apparent cause.
		94	33.0	22.3	30.6	52	0	1	2,900	2,620	1,327	116	....	2	....	....	3	6	Pitch pocket..	T.....	Irregular grain caused by knots.
Average....	.....	.....	38.9	27.3	18.1	55	0	.....	5,359	3,851	1,716	216									
Douglas fir (fire killed).	2 x 8..	95	30.2	26.2	24.8	58	0	1	7,560	4,520	1,680	242	....	....	....	....	....	....	.....	C. T.....	No apparent cause.
		96	32.4	26.8	23.0	59	0	1	7,150	4,170	1,915	229	....	....	....	....	....	....	.....	C. T.....	Do.
		97	33.3	26.9	22.3	54	0	2	7,080	3,830	2,091	226	....	....	....	....	....	....	.....	C. T.....	Do.
		98	52.3	29.3	9.8	60	0	1	7,060	3,860	1,870	225	1	....	2	....	6	....	.....	C. T.....	Do.
		99	36.7	30.1	22.3	59	0	2	6,780	3,700	2,115	216	....	....	....	....	1	....	Pitch pocket..	C. T.....	Do.
		100	34.6	27.3	13.9	55	0	2	6,740	4,120	1,863	216	1	....	....	....	9	....	.....	C. T.....	Do.
		101	40.5	28.6	22.1	60	0	2	6,530	4,290	1,969	208	....	....	....	....	....	....	Pitch pocket..	C.....	Do.

		102	34.6	30.1	12.4	57	0	2	6,470	3,710	1,785	206	....	....	3	....	2	....	.....do	C. T.....	Small corner knot 10 inches from center.
		103	38.9	26.6	31.4	53	0	2	6,380	4,080	1,742	204	....	....	....	....	....	....	Pitch pockets.	C. T.....	No apparent cause.
		104	49.8	27.3	12.5	57	0	2	6,230	4,060	1,800	199	....	....	2	....	10	....	.....do	C. T.....	Do.
		105	36.2	28.6	16.6	55	0	2	6,140	3,120	1,804	196	....	....	....	....	3	....	.....	T.....	Do.
		106	39.3	28.8	17.8	57	0	2	6,040	3,760	1,870	193	....	....	....	....	8	....	Pitch pocket..	T. C. T..	Irregular grain.
		107	32.5	25.1	14.6	54	0	2	5,940	4,130	1,729	190	4	....	1	....	7	2	.....	C. T.....	No apparent cause.
		108	40.8	27.8	14.6	60	0	1	5,390	3,180	1,838	172	....	....	4	1	7	1	Pitch pocket..	C. T.....	Do.
		109	45.6	23.6	6.3	50	0	4	5,280	3,410	1,632	168	....	....	4	....	11	1	.....	C. T.....	Small knot on top face, 16 inches from center.
		110	54.3	27.8	8.0	59	0	2	5,270	3,640	1,650	168	....	....	....	1	3	9	.....	C. T.....	Large corner knot 47 inches from center.
		111	37.8	25.7	12.5	54	0	1	5,220	3,550	1,803	166	....	....	....	....	7	....	.....	C. T.....	No apparent cause.
		112	35.5	26.8	9.6	45	0	2	5,180	3,870	1,771	165	2	....	1	....	11	....	.....	T.....	No apparent cause—brash failure.
		113	34.6	26.2	12.6	47	0	1	5,080	3,160	1,636	162	....	....	6	....	8	....	.....	C. T.....	Small knot across top face, 16 inches from center.
		114	33.6	26.8	23.9	61	0	1	5,070	3,170	1,756	162	....	....	1	....	6	....	.....	C. T.....	No apparent cause.
		115	35.5	23.3	23.3	49	0	2	4,930	3,640	1,634	157	....	....	....	....	....	....	.....	C. T.....	Do.
		116	33.2	24.7	15.5	49	0	1	4,850	3,170	1,723	154	1	....	....	1	13	3	.....	C. T.....	Large knot through piece near edge, 17 inches from center.
		117	30.9	25.8	14.8	47	0	1	4,830	3,380	1,591	154	5	1	1	....	19	....	.....	T. C.....	Small knot across bottom face, 40 inches from center.
		118	38.9	23.1	6.0	34	0	3	4,590	2,810	1,270	146	....	....	10	....	25	4	.....	C. T.....	No apparent cause.
		119	44.9	24.3	5.4	41	0	1	3,790	2,890	1,280	120	10	....	4	1	25	....	.....	C. T.....	Small knot on top face, 28 inches from center.
		120	30.1	26.7	10.4	43	0	1	3,630	2,520	1,312	115	....	2	1	3	2	8	.....	T.....	Irregular grain caused by knot 4 inches from center.
		121	34.6	27.6	7.9	55	0	2	3,450	2,450	1,319	109	2	2	8	1	10	3	.....	T.....	Large corner knot 29 inches from center.
		122	31.1	25.0	18.6	40	0	2	3,190	2,890	1,326	107	....	1	7	1	7	7	Pitch pocket..	T.....	Irregular grain caused by knot 36 inches from center.
		123	31.4	27.1	6.0	37	0	2	2,970	1,937	1,717	94	5	1	....	....	9	8	.....	T. C.....	Small corner knot 13 inches from center.
		124	31.3	23.1	23.5	44	0	2	2,910	2,570	1,058	92	9	1	1	....	22	3	.....	T. C.....	Small corner knot 4 inches from center.
		125	31.3	23.4	22.8	46	0	1	2,720	1,905	1,414	86	4	....	3	2	22	2	.....	T. C.....	Irregular grain caused by knot 22 inches from center.
Average.....			37.0	26.5	15.7	52	0	.....	5,305	3,403	1,676	169									
Shortleaf pine.....	8 x 16..	1	29.3	35.8	14.0	45	3	3	6,870	3,090	1,793	459	....	....	....	....	....	....	.....	S.....	No apparent cause.
		2	36.8	29.7	10.0	38	25	3	5,850	3,500	1,430	392	....	....	....	....	5	....	.....	C. T.....	Do.
		3	33.1	32.5	13.0	33	20	3	5,690	4,160	1,511	375	....	....	....	....	2	2	.....	S.....	Do.
		4	31.3	32.4	12.0	40	3	3	5,580	3,100	1,610	372	....	....	....	....	17	....	.....	C. T.....	Do.

TABLE 14.—*Data on individual bending tests of green timbers of commercial sizes*—Continued.

Species.	Size.	Reference number.	Moisture.	Dry weight per cubic foot.	Rings per inch.	Summer wood.	Sap.	Cross-section classification.	Modulus of rupture per square inch.	Fiber stress at elastic limit per square inch.	Modulus of elasticity per square inch.	Horizontal shear per square inch.	Number of knots.						Other defects.	Manner of failure.	Cause of first failure.
													Vol. I.		Vol. II.		Vol. III.				
													Less than 1½ inches.	1½ inches and over.	Less than 1½ inches.	1½ inches and over.	Less than 1½ inches.	1½ inches and over.			
	Inches.		*P. ct.*	*Lbs.*		*P. ct.*	*P. ct.*		*Lbs.*	*Lbs.*	*1,000 lbs.*	*Lbs.*									
Shortleaf pine	8 x 16	5	37.1	29.2	15.0	32	20	3	5,540	2,620	1,483	372	2				1	3		T	Small knot on lower corner 28 inches from center.
		6	63.6	31.8	14.0	43	55	3	5,490	3,060	1,460	367						1		C	No apparent cause.
		7	34.1	28.5	14.0	45	10	3	5,450	3,530	1,367	364					1	2		C	Do.
		8	44.5	26.6	9.0	38	15	3	5,260	3,080	1,161	352					2	5		C	Do.
		9	47.8	30.8	13.0	47	40	3	5,090	3,040	1,534	341					1			S	Do.
		10	30.0	29.0	12.0	25	3	3	5,030	3,540	1,247	336			3	1	2	4		C	Do.
		11	42.9	26.5	11.0	26	1	4	4,770	2,870	1,232	319					5	3	Heart shake	C	Do.
		12	44.0	29.0	8.5	37	20	3	4,350	2,630	1,428	291						2		S	Do.
Average			39.5	30.2	12.1	37	18		5,407	3,185	1,438	362									
Shortleaf pine	8 x 14	13	42.9	34.7	13.0	41	15	3	7,160	2,590	1,723	418								C	Do.
		14	31.1	32.5	15.0	38	1	3	6,920			404					3			T. C	Do.
		15	33.2	33.2	9.0	40	5	3	6,690	2,620	1,926	390				1	1	2		C	Do.
		16	73.7	30.5	14.0	35	45	3	6,170	4,050	1,549	361					2			C. T	Do.
		17	31.2	31.9	10.0	38	0	3	5,970	4,050	1,521	348	2				2			T. C. S	Irregular grain caused by knot 6 inches from center.
		18	49.5	30.0	13.0	33	30	3	5,820	3,450	1,377	341					2	1		C	No apparent cause.
		19	51.6	30.5	12.0	43	30	3	5,750	3,460	1,418	336					6	2		T. C	Irregular grain.
		20	42.2	30.9	22.0	43	25	3	5,620	3,780	1,538	328								S	No apparent cause.
		21	31.0	27.3	12.0	33	0	3	5,420	2,610	1,382	316			2		1			C	Do.
		22	52.8	24.9	11.0	28	15	3	4,830	2,600	1,103	281		2	1	1	2	5		C. T	Due to large corner knot.
		23	79.5	27.3	9.0	31	30	3	4,820	2,590	1,041	282				3	1	7		C	Due to large knot on upper face.
		24	31.0	33.9	12.0	38	2	3	4,200	3,770	1,856	245					3			S	No apparent cause.
Average			45.8	30.6	12.7	37	16		5,781	3,234	1,494	338									
Shortleaf pine	8 x 12	25	42.9	34.1	13.0	38	15	3	7,730	3,120	1,745	389					1			C	Do.
		26	40.9	37.1	16.0	39	25	3	7,690	3,880	1,813	387								C. S	Do.

		27	48.6	34.9	7.0	31	30	3	6,760	4,300	2,069	339					2			C	Do.
		28	31.8	35.6	11.0	47	0	3	6,350	3,100	1,784	321								S	Do.
		29	98.1	30.4	9.0	46	80	4	6,290	3,500	1,690	317	1				1			C	Do.
		30	67.0	31.8	9.0	35	55	3	6,220	3,500	1,923	313								C	Do.
		31	50.6	32.8	15.0	43	30	3	5,930	3,880	1,535	299					3			S	Do.
		32	31.0	31.2	13.0	32	3	3	5,840	3,890	1,543	294	2	1	1		5	4		T. C	Irregular grain caused by small knot 4 inches from center.
		33	70.8	33.4	9.0	43	55	3	5,830	3,120	1,647	294								C. T	No apparent cause.
		34	59.2	31.3	9.0	38	35	3	5,780	3,110	1,503	291								C	Do.
		35	46.7	29.9	7.0	35	10	1	5,700			286	3	1			5	2		T	Irregular grain caused by large knot at center.
		36	42.7	30.9	21.0	33	10	3	5,180	3,520	1,190	260			1		1	2		T	Irregular grain caused by corner knot 52 inches from center.
		37	36.7	29.2	11.0	42	21	3	5,180	3,090	1,333	261						1		C	No apparent cause.
		38	51.0	29.6	8.0	37	30	3	5,140	3,160	1,474	258					7	2		T. C	Do.
		39	69.2	27.5	23.0	38	40	3	5,040	2,720	1,272	254								C	Due to burl at center of top face.
		40	57.1	29.6	9.0	36	30	3	4,950	3,120	1,271	249			1	2	3	6		C. T	No apparent cause.
		41	88.9	26.6	7.0	36	55	3	4,920	3,520	1,280	247	2		1		7	4		C	Do.
		42	84.1	26.1	17.0	25	50	3	4,870	2,720	1,117	245								C. S	Do.
		43	36.3	30.2	11.0	36	5	3	4,760	3,100	1,405	240		1	1	1	1	1		T	Irregular grain caused by large knot on lower face
		44	34.4	28.5	14.0	32	1	3	4,690	3,900	1,490	235			2	1	4	2		C. T	No apparent cause.
		45	31.4	28.2	9.0	38	2	4	4,500	3,110	1,184	226		2		1	1	1		T	Large knot at center of lower face.
		46	39.0	26.3	11.0	35	10	3	4,490	2,710	1,194	227	1	1			3	5		T	Small knot at center of lower face.
		47	58.3	31.0	12.0	29	35	3	4,180	2,710	1,187	211			2		2	1		T. C	Large knot at center of lower face.
		48	35.2	28.2	13.0	30	0	3	4,050	2,310	1,390	204	1	2		1	8	10		T	Large corner knot 52 inches from center.
Average			52.2	30.6	11.8	36	26		5,503	3,265	1,480	277									
Shortleaf pine	5 x 8	49	34.5	31.6	10.0	45	15	3	6,760	4,530	1,546	223			1					T. C	No apparent cause.
		50	38.8	30.4	10.0	38	26	4	6,760	3,660	1,627	224			1					C. T	Do.
		51	36.8	33.2	14.0	45	5	3	6,580	3,670	1,720	218					3			C	Do.
		52	31.7	31.4	19.0	40	18	1	6,490	4,230	1,705	215					1			C. T	Do.
		53	30.4	31.0	15.0	47	6	3	6,450	3,950	1,590	214			1		2			C	Small knot on upper face 35 inches from center.
		54	39.7	28.9	15.0	45	14	3	6,430	4,200	1,583	103	2				5	2		T	Irregular grain caused by knots.
		55	61.6	31.3	12.0	39	59	3	6,260	3,360	1,667	207					3			C	No apparent cause.
		56	37.7	29.9	10.0	38	20	3	6,200	3,340	1,560	206					1			C. T	Do.
		57	53.7	29.6	10.0	40	55	3	6,060	3,380	1,426	201					8	5		C. T	Do.
		58	31.3	32.5	20.0	43	0	3	6,010	4,510	1,700	199	1				4			T. C	Irregular grain due to knot near edge.
		59	67.1	27.5	8.0	33	60	4	5,950	3,370	1,580	197								C	No apparent cause.
		60	41.7	32.7	12.0	55	60	4	5,920	3,650	1,545	196								C. T	Do.
		61	70.7	30.4	12.0	42	65	3	5,830	3,690	1,696	192								C	Burl on top face 24 inches from center.

TABLE 14.—*Data on individual bending tests of green timbers of commercial sizes*—Continued.

Species.	Size.	Reference number.	Moisture.	Dry weight per cubic foot.	Rings per inch.	Summer wood.	Sap.	Cross-section classification.	Modulus of rupture per square inch.	Fiber stress at elastic limit per square inch.	Modulus of elasticity per square inch.	Horizontal shear per square inch.	Number of knots.						Other defects.	Manner of failure.	Cause of first failure.
													Vol. I.		Vol. II.		Vol. III.				
													Less than 1½ inches.	1½ inches and over.	Less than 1½ inches.	1½ inches and over.	Less than 1½ inches.	1½ inches and over.			
	Inches.		*P. ct.*	*Lbs.*		*P. ct.*	*P. ct.*		*Lbs.*	*Lbs.*	*1,000 lbs.*	*Lbs.*									
Shortleaf pine	5 x 8..	62	41.9	26.3	6.0	35	44	3	5,680	3,370	1,498	188	....	....	1	....	1	....		C. T.	No apparent cause.
		63	54.9	27.6	10.0	38	35	3	5,660	2,530	1,517	187	....	1	1	3	....	1		C.	Large knot on top face 12 inches from center.
		64	44.9	29.3	13.0	43	28	3	5,650	3,110	1,383	187	....	....	5	....	....	....		C. T.	Large knot on top face 18 inches from center.
		65	30.4	29.1	15.0	39	5	3	5,590	4,470	1,404	186	3	....	....	....	2	....		T. C.	No apparent cause.
		66	61.5	25.3	10.0	37	65	3	5,440	3,380	1,586	180	1	....	....	....	11	1		T.	No apparent cause—brash failure.
		67	53.2	29.6	12.0	41	65	3	5,370	3,380	1,543	178	....	....	....	....	1	....		C.	No apparent cause.
		68	73.4	26.1	11.0	38	80	3	5,130	3,640	1,214	170	....	....	....	....	1	....		C.	Do.
		69	35.2	26.8	9.0	30	28	3	4,910	3,100	1,199	162	....	....	2	....	....	....		C. T.	Do.
		70	102.5	25.1	9.0	36	76	3	4,870	2,850	1,238	161	....	....	....	4	7	6		C.	Large knot on top face 12 inches from center.
		71	35.0	27.5	8.0	37	12	3	4,170	2,820	999	138	3	2	....	....	11	8		T.	Cross-grain.
		72	39.3	29.3	7.0	36	25	3	3,390	2,260	1,120	112	....	4	....	3	3	5		T.	Large corner knot 5 inches from center.
Average	.....	.....	47.8	29.3	11.5	40	36	.....	5,732	3,519	1,485	185									
Western larch	8 x 16..	1	53.9	27.8	21.0	.....	0	3	6,350	4,330	1,414	414	....	....	....	....	1	3	Checks	C. S.	No apparent cause.
		2	56.0	28.2	25.8	.....	0	1	6,250	3,670	1,227	398	....	....	1	....	2	....	Pitch streak	C. T.	Do.
		3	57.8	33.2	22.5	.....	0	3	6,190	5,290	1,823	403	....	....	....	....	2	1	Checks	S.	Due to checks.
		4	46.0	28.9	19.1	.....	0	3	6,140	3,970	1,620	386	1	....	1	....	15	....		C. T.	No apparent cause.
		5	62.0	29.7	18.6	.....	0	3	5,940	4,770	1,717	381	....	....	....	....	9	....		C. S.	Do.
		6	49.3	26.7	20.4	.....	0	1	5,780	3,750	1,379	3	2	....	....	....	3	....		C. T.	Do.
		7	48.0	28.6	23.9	.....	1	3	5,470	4,180	1,378	3.	....	....	3	....	20	....		C. T.	Do.
		8	53.6	29.8	26.3	.....	0	1	5,460	3,450	1,424	347	....	....	....	....	....	....		C. T.	Do.
		9	41.5	24.7	36.7	.....	0	1	5,460	3,340	1,097	356	....	....	....	....	....	....		C. T.	Do.
		10	46.2	29.1	20.7	.....	0	3	5,420	3,850	1,543	353	....	....	2	1	1	2	Checks	C. S.	Do.
		11	64.5	32.1	22.2	.....	0	3	5,400	3,120	1,527	352	....	....	1	....	7	....	....do	C. T.	Do.
		12	41.6	27.1	19.2	.....	2	3	5,160	3,820	1,283	331	....	....	1	....	19	1		C. T.	Small knot on upper face 8 inches from center.
		13	46.6	27.5	14.4	.....	3	3	5,070	4,030	1,255	323	2	....	10	3	39	5		C. T.	Due to knots on upper face.

		14	66.8	29.0	25.7		0	3	5,050	3,270	1,267	326		1	2		8		Pitch streaks	S.	No apparent cause.
		15	46.5	24.9	25.0		1	3	4,950	3,350	1,200	318			2		8	5		T. C.	No apparent cause—brash failure.
		16	40.7	26.8	23.8		0	3	4,930	3,580	1,086	317					20	2		C. T.	No apparent cause.
		17	51.0	27.7	22.6		0	1	4,740	3,250	1,221	302	5	1	3		25	1		T. C.	Irregular grain.
		18	66.6	22.1	45.4		0	1	4,680	2,660	925	301							Pitch pocket	C. T.	No apparent cause.
		19	43.3	25.7	21.0		0	3	4,640	3,240	1,126	295					12	1		C. T. S.	Do.
		20	56.7	30.0	22.6		0	1	4,570	2,890	1,213	298	1			5	1	5		C. T.	Do.
		21	46.1	27.4	22.0		2	1	4,550	3,340	1,145	294			1	3	18	2		S.	Do.
		22	52.1	31.4	30.8		0	3	4,390	3,590	1,340	286					3		Checks	C. S.	Do.
		23	46.6	26.8	25.0		0	1	4,100	2,990	1,090	269	1				35	1		C. T.	Do.
		24	60.7	28.4	27.9		0	3	4,050	2,810	1,592	259					2		Checks	C. S.	Do.
		25	57.6	29.3	20.4		0	1	3,470	2,840	1,178	227	8	1	14		8	1		T.	Irregular grain.
		26	50.9	24.5	34.7		0	1	3,220	1,920	920	210	6	3	3	2	3	3		C. T.	Small knot in upper face.
		27	45.5	27.5	28.1		0	3	3,040	2,280	1,181	192	4		5		40	2		T. C.	Irregular grain caused by small knot on lower face 36 inches from center.
		28	49.8	25.6	28.2		0	1	2,990	2,210	997	191	8		16		39	3		T.	Knot cluster 30 inches from center.
		29	54.0	33.1	25.2		0	3	2,910	2,380	1,587	190								S.	No apparent cause.
		30	42.0	25.7	25.0		1	3	2,770	1,989	1,182	177	4	2	1	1	13	3		T. C.	Small corner knot 28 inches from center.
		31	43.2	23.2	38.0		0	1	2,570	2,250	922	163							Cross grain	T.	Cross grain.
		32	45.8	30.0	26.9		5	3	2,500	2,410	842	158	6	4	9	4	25	7		T.	Large corner knot 16 inches from center.
Average			51.0	27.9	25.3		.5		4,632	3,276	1,272	298									
Western larch	8 x 12	33	56.5	34.0	23.9		0	3	7,340	4,500	1,752	356							Checks	C. S.	No apparent cause.
		34	45.9	30.7	22.8		0	1	7,310	3,830	1,719	354					4		do	C. S.	Do.
		35	59.0	33.4	21.4		0	1	7,170	3,110	1,472	348					6			C. T.	Do.
		36	52.6	29.4	20.0		0	1	6,550	4,670	1,474	311					8	1		C. T.	Do.
		37	52.0	29.9	29.9		0	3	6,390	3,460	1,614	310			1		9			C. T.	Do.
		38	58.1	28.8	24.1		0	3	6,360	3,830	1,599	308			2	2	10	2		C. T.	Do.
		39	39.5	32.1	18.0		0	3	6,300	4,440	1,748	299			5		14	1		C. T.	Small knot on upper face.
		40	39.5	33.5	24.8		0	3	6,010	4,150	1,708	291	1		2		4	1		C. T.	No apparent cause.
		41	45.0	27.7	17.8		0	3	5,990	3,120	1,499	291			6		8	1		C. T.	Do.
		42	63.3	26.9	19.8		0	1	5,980	3,820	1,518	290	1	3			1	1		C. T.	Do.
		43	53.8	29.6	13.9		0	1	5,790	4,300	1,462	276	5	1	4	2	23	1		C. T.	Do.
		44	47.0	26.9	30.0		0	1	5,730	4,030	1,196	271			1	1	14	2		C. T.	Large knot on upper face.
		45	50.5	30.5	24.1		0	1	5,620	3,450	1,283	273			3		2			C. T.	No apparent cause.
		46	48.0	29.6	20.6		0	3	5,600	3,820	1,412	272	2		5	3	6	3		C. T.	Do.
		47	40.5	28.8	16.5		0	3	5,360	4,300	1,431	257	1	1	9	1	22			C. T.	Small knot on upper face.
		48	38.0	28.7	27.6		0	1	5,270	4,260	1,481	253			12		13		Checks	C. S.	Due to knot cluster 12 inches from center on top face.
		49	38.8	24.9	25.7		0	3	5,150	4,030	1,149	244	1		6	1	27	2		C. T.	No apparent cause.
		50	59.0	28.0	30.2		0	3	4,910	2,050	694	232	2		4		18	1		C. T.	Do.
		51	46.4	25.6	33.5		0	4	4,640	2,070	1,111	226	1	2			3		Shake	S. C. T.	Due to shake.
		52	53.0	28.6	27.4		0	1	4,590	3,330	1,133	217	3		5		25	4		C. T.	Small knot on upper face 12 inches from center.

TABLE 14.—*Data on individual bending tests of green timbers of commercial sizes*—Continued.

Species.	Size.	Reference number.	Moisture.	Dry weight per cubic foot.	Rings per inch.	Summer wood.	Sap.	Cross-section classification.	Modulus of rupture per square inch.	Fiber stress at elastic limit per square inch.	Modulus of elasticity per square inch.	Horizontal shear per square inch.	Number of knots.						Other defects.	Manner of failure.	Cause of first failure.
													Vol. I.		Vol. II.		Vol. III.				
													Less than 1½ inches.	1½ inches and over.	Less than 1½ inches.	1½ inches and over.	Less than 1½ inches.	1½ inches and over.			
	Inches.		*P. ct.*	*Lbs.*		*P. ct.*	*P. ct.*		*Lbs.*	*Lbs.*	*1,000 lbs.*	*Lbs.*									
Western larch	8x12	53	47.5	29.0	24.9	.....	0	1	4,510	2,780	987	214	11	1	6	4	37	9	.....	T	Irregular grain caused by knot cluster at center.
		54	60.5	30.0	20.7	.....	0	3	4,490	3,800	1,285	218	5	2	4	1	7	1	.....	T	Brash failure starting at small knot on lower corner near center.
		55	55.5	26.6	23.6	.....	0	1	4,490	2,750	1,334	212	2	....	5	....	20	1	Pitch seam	C. T.	No apparent cause.
		56	52.9	24.5	19.8	.....	0	1	4,270	2,680	1,247	204	1	1	4	....	7	....	.....	C. T.	Do.
		57	49.0	28.9	26.1	.....	0	3	4,220	3,100	1,138	205	3	....	7	3	6	6	.....	T. C.	Small knot on corner 30 inches from center.
		58	50.5	25.5	20.2	.....	0	1	4,180	2,600	1,179	198	8	....	4	....	20	2	.....	C. T.	Small knot on upper corner 8 inches from center.
		59	64.3	31.6	22.1	.....	0	3	3,960	2,760	1,396	192	2	....	4	....	2	10	.....	C. S.	No apparent cause.
		60	43.8	28.2	21.5	.....	0	3	3,870	2,370	1,025	182	7	....	3	....	19	1	.....	T. C.	Knot cluster on lower corner 44 inches from center.
		61	40.0	25.2	24.5	.....	0	1	3,730	1,810	965	178	1	2	8	1	24	3	.....	T	Large knot 15 inches from center.
		62	57.9	27.2	20.5	.....	0	3	2,800	2,070	928	135	2	2	1	5	7	7	Cross grain	T	Cross grain.
Average	.....	.....	50.3	28.8	23.2	.....	0	.....	5,286	3,376	1,331	254									
Western larch	5x8	63	61.1	33.4	28.0	.....	0	1	7,260	4,310	1,531	230	....	....	....	....	2	....	.....	C. T.	No apparent cause.
		64	49.2	30.1	23.0	.....	0	1	6,910	4,100	1,790	222	....	....	1	....	1	1	.....	C. T.	Do.
		65	44.0	29.6	24.0	.....	0	1	6,900	4,680	1,807	218	3	....	1	....	10	1	.....	C. T.	Do.
		66	57.1	30.9	23.0	.....	0	1	5,910	3,650	1,470	187	....	....	....	....	....	....	.....	C. T.	Do.
		67	54.8	29.6	23.0	.....	0	1	5,900	2,980	1,610	187	1	....	1	....	5	2	.....	C. T.	Do.
		68	60.5	28.7	17.0	.....	0	2	5,660	3,330	1,635	179	....	....	1	....	....	....	.....	C. T.	Do.
		69	61.5	33.4	22.5	.....	0	1	5,260	4,400	1,600	166	4	....	....	....	5	....	.....	T	Small corner knot at center of lower edge.
		70	41.8	28.0	19.5	.....	0	1	5,260	3,710	1,467	166	....	....	....	....	15	3	.....	C. T.	No apparent cause.
		71	58.0	29.2	24.5	.....	0	4	5,050	3,310	1,518	160	3	....	2	....	1	....	Cross grain	C. T.	Do.
		72	71.5	32.5	30.0	.....	1	1	4,820	2,960	1,164	153	....	....	....	....	....	....	Curl	T	Irregular grain.

		73	50.5	27.1	22.5		0	1	4,510	3,270	1,210	143	4		5	2	11	3		T.C.	Cross grain.
		74	52.9	32.2	28.0		0	1	4,380	3,740	1,135	128	6		4		11	2		T.C.	Small corner knot 8 inches from center.
		75	62.0		43.0		0	1	3,490	2,630	888	111	2		2		1			C.T.	No apparent cause.
		76	59.3	32.2	30.0		0	2	3,320	2,320	1,219	105								S.	Do.
Average			56.0	30.5	25.6		0		5,331	3,528	1,432	169									
Loblolly pine	8 x 16	1	36.0	32.9	5.6		0	3	6,620	4,080	1,540	442					1			C.T.	No apparent cause.
		2	39.0	36.3	4.5		18	3	6,560	3,370	1,414	440					1			C.T.	Do.
		3	52.0	31.9	7.8		21	3	6,470	3,740	1,561	431					2			S.	Do.
		4	27.9	35.2	6.3	53	17	1	6,440	3,250	1,464	435					4		Checks	T.	Do.
		5	40.0	36.6	11.7		5	3	6,100	3,560	1,785	408					6		do	S.	Apparently influenced by checks.
		6	44.0	37.5	5.4		21	3	5,870	3,370	1,595	392								C.	No apparent cause.
		7	79.0	29.8	4.9		75	3	5,640	3,020	1,370	376					2	3		C.T.	Do.
		8			3.5		65	3	5,590	2,950	1,405	375					2			C.S.	Do.
		9	55.0	33.8	7.8		25	3	5,410	3,030	1,540	361					1			C.	Do.
		10	24.1	26.5	5.8	42	25	3	5,360	3,080	1,183	445					7	2		S.	Do.
		11	72.0	30.2	4.4		56	3	5,330	3,460	1,361	354					3			C.T.	Do.
		12			3.3		78	3	4,730	2,660	1,234	317		1		1	2	9		C.T.	Do.
		13	52.0	31.9	5.0		16	3	4,650	2,285	1,145	310					7	1		C.	Due to diagonal grain.
		14	28.0	33.1	7.3	46	22	3	4,610	2,870	1,515	380					3		Checks	S.	Due to checks.
		15	40.0	31.9	10.4		4	3	4,440	3,380	1,470	296								S.	No apparent cause.
		16	44.6	24.6	4.8	41	60	3	4,210	2,160	1,230	347	2				9	3		T.C.	Irregular grain caused by knot.
		17	54.1	25.4	4.8	37	3	3	3,670	2,330	1,089	301	3				8	5		T.	Started at small sound knot on corner.
Average			45.8	31.8	6.1	44	30		5,394	3,094	1,406	383									
Loblolly pine	5 x 12	18					55	3	7,260	4,400	1,650	363					8	1		C.T.	No apparent cause.
		19	47.0	34.6	6.7		25	3	7,120	4,370	1,785	237					1	4		C.	Do.
		20			6.0		23	3	7,060	3,900	2,040	356					7			C.T.	Do.
		21					44	3	6,740	4,220	1,770	334					12	4		C.	Do.
		22	47.0	28.7	9.2		15	3	6,720	4,180	1,920	336					7	3		C.T.S.	Do.
		23			6.6		93	3	6,700	3,950	1,790	329					5	2		C.	Do.
		24	67.0	36.1	7.5		50	3	6,570	3,560	1,600	329					4	2		C.T.	Do.
		25			6.5		65	3	6,510	3,370	1,560	325					3	5		C.T.	Do.
		26	28.0	32.6			5	3	6,450	3,165	1,580	210							Checks	S.	Due to checks.
		27	75.0	31.6	6.7		62	3	6,260	3,120	1,665	207								C.T.	No apparent cause.
		28	82.0	33.1	4.5		70	1	6,240	3,800	1,445	201								C.T.	Do.
		29			5.0		45	3	6,130	3,810	1,470	307					10	2		C.T.	Do.
		30			20.0		12	3	6,100	4,540	1,750	305					3	1		S.	Do.
		31	86.0	33.6			78	1	6,080	4,290	1,930	202								S.	Do.
		32	60.0	29.3	5.5		72	3	5,960	3,310	1,660	298					6	6		C.	Do.
		33					35	3	5,930	3,620	1,600	294					17	1		C.	Do.
		34	30.0	32.1			18	3	5,890	3,300	1,180	196				1	12	8		C.T.	Large knot 4 inches from center on top face.
		35	40.0	30.8	5.0		15	3	5,830	3,270	1,180	199				2	2	1		C.T.	Large knot 11 inches from center on top corner.
		36	62.0	27.5	6.1		55	3	5,820	3,490	1,361	291					8	1		C.	No apparent cause.
		37	48.0	30.0			10	3	5,800	3,010	1,390	195					2	2		C.T.	Do.
		38			6.0		45	3	5,770	3,820	1,875	288			1		16	1		C.	Do.

TABLE 14.—*Data on individual bending tests of green timbers of commercial sizes*—Continued.

Species.	Size.	Reference number.	Moisture.	Dry weight per cubic foot.	Rings per inch.	Summer wood.	Sap.	Cross-section classification.	Modulus of rupture per square inch.	Fiber stress at elastic limit per square inch.	Modulus of elasticity per square inch.	Horizontal shear per square inch.	Number of knots.						Other defects.	Manner of failure.	Cause of first failure.
													Vol. I.		Vol II.		Vol. III.				
													Less than 1½ inches.	1½ inches and over.	Less than 1½ inches.	1½ inches and over.	Less than 1½ inches.	1½ inches and over.			
	Inches.		*P. ct.*	*Lbs.*		*P. ct.*	*P. ct.*		*Lbs.*	*Lbs.*	*1,000 lbs.*	*Lbs.*									
Loblolly pine	5 x 12	39			9.0		0	3	5,760	3,720	1,416	288	1			1	4	8		C.	Large knot 14 inches from center on upper face.
		40	70.0	30.6	6.9		48	3	5,750	3,871	1,623	287				1	15	1		C.	No apparent cause.
		41	32.0	36.1	5.7		5	3	5,720	2,500	1,150	191	1	1		2	8	6		T.	Irregular grain due to large knot.
		42			5.3		47	3	5,700	3,690	1,610	278					10	2		C.	No apparent cause.
		43	54.0	32.4	5.4		30	3	5,650	3,320	1,460	190					1			C. T.	Do.
		44	101.0	28.7	6.0		66	3	5,600	3,070	1,442	280					6	6		C.	Wavy grain on upper edge.
		45	33.0	28.4	4.3		23	3	5,440	2,480	1,376	181	1			1	10	2		C. T.	No apparent cause.
		46	68.0	29.6	7.6		41	3	5,430	3,370	1,540	274	1				11	8		C.	Do.
		47	103.0	29.5	6.2		77	3	5,430	3,200	1,490	181					5			C.	Do.
		48	62.0	27.5	5.5		42	3	5,420	3,310	1,260	271					15	3		C. T.	Do.
		49	39.0	28.6	4.1		20	3	5,400	3,790	1,468	186					1	2		C. T.	Do.
		50	41.0	30.4	4.5		10	3	5,370	3,320	1,450	182		1	1	1	2	2		C. T.	Large knot on upper edge.
		51	101.0	28.7	5.8		50	3	5,370	3,170	1,583	269					9	6		C.	Wavy grain on upper edge.
		52	40.0	30.0	4.8		10		5,300	3,060	1,290	267		1		2				T.	Large knot on corner 7 inches from center.
		53	34.0	29.5	4.0		7	3	5,280	3,350	1,285	179				1	3			T. C.	Small knot and wavy grain.
		54	48.0	29.1	4.7		30	3	5,230	2,680	1,375	174	2		1	1	8	4		C. T.	No apparent cause.
		55			8.1		32	3	5,210	3,300	1,310	260	1	1		1	12	12		T.	Rotten knot on corner 75 inches from center.
		56	67.0	36.1	6.6		68	3	5,210	3,140	1,650	260					11		Wavy grain	T.	Wavy grain 14 inches from center.
		57	71.0	28.9	5.7		42	3	5,200	3,180	1,450	261		1		1	5	4		T. C.	Wavy grain at center.
		58			5.1		45	3	5,200	2,280	1,400	256	1				6	7		C. T.	No apparent cause.
		59			6.2		55	3	5,200	2,095	1,380	258		1	1	2	13	8		T. C.	Wavy grain 16 inches from center.
		60	38.0	29.3	10.0		25	1	5,150	2,730	1,255	257					3	4		C. T.	No apparent cause.
		61			8.2		45	3	5,150	2,650	1,290	253			1	3	8	14		C. T.	Large knot on corner.

62	45.0	29.7	4.8	.....	28	3	5,140	3,090	1,324	175	....	1	....	2	7	1	.....	C.T.....	Large knot on corner 21 inches from center.
63	77.0	31.2	5.8	.....	85	1	5,040	2,770	1,408	254	.....	.....	3	3	5	7	.....	C.T.....	Large knot on corner.
64	67.0	31.6	7.2	.....	55	3	5,000	3,060	1,475	167	.....	.....	.....	.....	4	4	Wavy grain...	T.C.....	Wavy grain 19 inches from center.
65	.....	.....	6.9	.....	45	3	4,990	3,180	1,334	249	.....	.....	.....	.....	7	4	.....	C.....	No apparent cause.
66	86.0	30.6	6.5	.....	45	3	4,980	3,260	1,500	249	.....	.....	1	.....	4	6	.....	C.T.....	Slight wave in grain.
67	.....	.....	5.3	.....	60	3	4,960	3,200	1,250	250	.....	.....	1	3	8	7	.....	C.....	Large knot 12 inches from center.
68	77.0	31.8	7.1	.....	65	3	4,950	2,600	1,365	245	.....	.....	2	2	8	3	.....	C.....	No apparent cause.
69	.....	.....	5.3	.....	50	3	4,950	2,350	1,565	246	1	.....	1	1	5	13	.....	T.C.....	Small corner knot 27 inches from center.
70	.....	.....	6.5	.....	80	3	4,920	3,200	1,545	246	.....	.....	.....	.....	7	4	.....	C.T.....	No apparent cause.
71	37.0	29.3	5.0	.....	20	3	4,890	3,490	1,260	168	.....	.....	.....	1	3	3	Cross grain....	T.....	Cross grain 20 inches from center.
72	.....	.....	6.1	.....	55	3	4,890	2,790	1,415	242	.....	1	.....	2	9	14	.....	T.C.....	Large corner knot 28 inches from center.
73	.....	.....	4.7	.....	33	3	4,880	3,550	1,430	244	.....	.....	1	3	7	12	.....	T.C.....	Wavy grain 13 inches from center.
74	73.0	32.8	4.0	.....	68	3	4,870	2,490	1,035	241	.....	.....	3	1	6	5	Wavy grain...	T.....	Wavy grain 24 inches from center.
75	46.0	30.1	.....	.....	98	3	4,860	2,880	1,063	170	.....	.....	.....	.....	.....	.....	Checks.....	T.....	No apparent cause.
76	71.0	30.6	.....	.....	50	3	4,840	3,260	1,470	163	1	.....	2	2	1	3	Wavy grain...	T.C.....	Wavy grain 8 inches from center.
77	88.0	31.2	4.3	.....	85	3	4,770	2,630	1,544	243	.....	.....	3	3	4	7	.....	C.T.....	Large knot on upper corner.
78	71.0	33.3	6.4	.....	83	3	4,770	2,450	1,340	239	.....	.....	1	1	11	9	Wavy grain...	C.T.....	Small corner knot 11 inches from center.
79	66.0	31.2	6.3	.....	67	.....	4,760	3,140	1,430	240	1	1	.....	1	.....	1	.....	T.....	Wavy grain 7 inches from center.
80	64.0	29.4	6.6	.....	45	3	4,710	3,000	1,400	238	.....	.....	.....	1	19	1	.....	C.....	No apparent cause.
81	42.0	31.2	5.4	.....	10	3	4,670	3,170	1,360	232	1	1	1	1	6	12	.....	T.....	Wavy grain 46 inches from center.
82	37.0	33.1	4.7	.....	18	3	4,630	3,140	1,346	157	1	1	3	1	8	9	.....	T.....	Irregular grain at knot 28 inches from center.
83	101.0	27.3	.....	.....	88	3	4,630	2,790	1,340	236	1	.....	.....	2	12	10	.....	T.....	Slight wave in grain—rather brash.
84	.....	.....	5.0	.....	35	3	4,560	2,810	1,405	228	.....	.....	1	2	9	10	Pitch pocket..	T.....	Pitch pocket on bottom 15 inches from center.
85	28.0	30.8	3.3	.....	3	3	4,550	2,520	989	155	.....	.....	1	2	6	...	.....	C.T.....	Large corner knot 19 inches from center.
86	34.0	29.6	4.3	.....	8	3	4,500	2,700	1,129	156	2	1	.....	2	3	2	.....	T.C.....	Small corner knot 17 inches from center.
87	120.0	28.3	.....	.....	100	1	4,460	2,750	1,280	148	.....	.....	.....	1	1	1	.....	T.C.....	Irregular grain at knot 16 inches from center.
88	.....	.....	4.8	.....	41	3	4,380	3,180	1,405	219	.....	.....	1	1	6	15	.....	T.....	Wavy grain 9 inches from center.
89	52.0	34.3	6.2	.....	45	3	4,370	2,820	1,620	218	.....	.....	2	.....	8	4	Wavy grain...	T.....	Wavy grain 44 inches from center.
90	.....	.....	6.0	.....	92	3	4,350	2,145	1,345	214	.....	3	.....	1	6	7	.....	C.T.....	Large knot on top face.
91	.....	.....	.....	.....	42	3	4,300	3,240	1,292	215	.....	.....	1	.....	10	5	.....	T.....	Wavy grain 31 inches from center.

TABLE 14.—*Data on individual bending tests of green timbers of commercial sizes*—Continued.

Species.	Size.	Reference number.	Moisture.	Dry weight per cubic foot.	Rings per inch.	Summer wood.	Sap.	Cross-section classification.	Modulus of rupture per square inch.	Fiber stress at elastic limit per square inch.	Modulus of elasticity per square inch.	Horizontal shear per square inch.	Number of knots.						Other defects.	Manner of failure.	Cause of first failure.
													Vol. I.		Vol. II.		Vol. III.				
													Less than 1½ inches.	1½ inches and over.	Less than 1½ inches	1½ inches and over.	Less than 1½ inches.	1½ inches and over.			
	Inches.		*P. ct.*	*Lbs.*		*P. ct.*	*P. ct.*		*Lbs.*	*Lbs.*	*1,000 lbs.*	*Lbs.*									
Loblolly pine.....	5 x 12..	92	73.0	27.5	4.0	.....	57	3	4,290	2,010	1,070	213	....	....	1	3	5	13	.....	C.....	Large corner knot 4 inches from center.
		93	41.0	29.8	3.6	.....	8	3	4,250	2,300	887	141	2	....	3	1	5	4	.....	C. T.....	Large corner knot 7 inches from center.
		94	.....	.....	6.4	.....	47	3	4,220	3,070	1,200	211	....	1	1	1	10	5	.....	C. T.....	Large corner knot 19 inches from center.
		95	92.0	26.3	3.8	.....	65	3	4,200	2,710	1,340	146	....	....	1	1	4	4	.....	T. C.....	Wavy grain 20 inches from center.
		96	71.0	25.3	4.2	.....	28	3	4,170	2,310	935	136	....	....	3	2	2	6	Wavy grain...	T. C.....	Wavy grain 5 inches from center.
		97	106.0	31.9	2.9	.....	85	3	4,120	2,280	1,020	135	1	1	2	3	3	4	.....	T.....	Large knot 42 inches from center.
		98	42.0	30.3	8.0	.....	27	1	4,060	2,210	974	140	5	1	3	....	3	1	.....	C. T.....	Large corner knot 6 inches from center.
		99	41.0	32.9	2.6	.....	18	3	4,040	2,670	1,390	137	....	2	....	....	2	4	Pitch pocket..	T.....	Pitch pocket and wavy grain 27 inches from center.
		100	44.0	39.0	4.9	.....	40	3	3,930	2,560	1,260	131	....	1	....	3	3	6	.....	T.....	Large knot on lower face 4 inches from center.
		101	.....	.....	5.0	.....	47	3	3,920	2,800	1,360	196	....	....	1	1	6	13	.....	T.....	Wavy grain at knot 4 inches from center.
		102	76.0	29.3	5.6	.....	65	3	3,860	2,220	1,150	192	1	2	....	1	9	8	.....	T. C.....	Large corner knot 36 inches from center.
		103	.....	.....	.....	.....	65	3	3,640	2,440	1,140	182	....	....	....	4	4	7	.....	T.....	No apparent cause.
		104	.....	.....	13.8	.....	49	3	3,550	2,360	1,170	176	....	....	....	4	10	11	.....	T.....	Sudden failure due to knot.
		105	.....	.....	5.7	.....	25	3	3,380	2,560	1,170	169	....	1	....	1	4	12	.....	T.....	Due to large knot on bottom face 8 inches from center.
		106	70.0	29.0	5.0	.....	40	3	3,250	2,720	1,300	165	....	....	2	4	5	10	Wavy grain...	T.....	Wavy grain 26 inches from center.
		107	58.0	33.5	3.6	.....	60	3	3,140	1,600	949	101	....	2	1	4	2	5	.....	T.....	Large corner knot 19 inches from center.
		108	54.0	28.1	3.2	.....	8	3	3,110	2,050	1,388	155	1	2	2	2	5	9	.....	T.....	Large knot on bottom

		109	50.0	28.7	.....	.....	35	3	2,810	2,260	942	94	1	2	....	2	....	6	.....	T.....	face 14 inches from center. Large corner knot 12 inches from center.
		110	.....	.....	5.7	.....	21	3	2,680	2,500	1,010	134	....	3	....	6	2	17	.....	T.....	Large corner knot 35 inches from center.
		111	.....	.....	4.4	.....	10	3	2,300	1,860	912	114	....	2	1	2	7	9	.....	T.....	Large knot in lower face 15 inches from center.
Average.....	.....	.....	60.9	30.7	5.9	.....	44	.....	5,028	3,030	1,383	221									
Tamarack.....	6 x 12..	1	43.4	30.3	16.6	40	0	3	5,710	3,138	1,180	325	.....	.....	1	.....	.....	1	.....	C. T.....	No apparent cause.
		2	64.5	30.1	16.5	35	6	3	5,700	3,330	1,383	329	.....	.....	.....	.....	.....	.....	.....	C. T.....	Do.
		3	72.1	30.6	24.4	40	4	3	5,530	3,490	1,160	313	.....	.....	.....	.....	.....	.....	Rot at butt...	S.....	Rotten streaks.
		4	49.0	28.6	11.3	40	0	3	5,150	2,850	1,250	294	.....	.....	1	.....	14	1	.....	C. T.....	Small corner knot.
		5	62.9	27.0	17.2	35	1	3	5,080	3,550	1,352	293	.....	.....	2	.....	4	3	.....	C. T.....	No apparent cause.
		6	69.7	29.7	22.6	40	6	3	4,900	3,384	1,034	272	.....	.....	1	.....	4	.....	.....	T.....	Do.
		7	46.5	29.5	12.1	35	2	3	4,630	3,430	1,245	261	....	1	.....	1	3	.....	.....	T.....	Small corner knot 23 inches from center.
		8	67.5	28.7	16.8	30	0	3	4,620	3,230	1,348	254	2	1	4	1	27	1	.....	C. T.....	No apparent cause.
		9	57.0	30.5	21.0	40	0	3	4,610	2,688	1,218	263	.....	.....	.....	.....	.....	.....	Rot streaks...	T. S.....	Do.
		10	51.5	27.2	13.6	20	4	3	4,520	2,650	1,245	257	3	2	1	1	20	2	.....do.....	T. C.....	Small corner knot 19 inches from center.
		11	41.5	30.6	11.5	30	1	3	4,375	3,800	1,538	241	5	....	5	1	21	....	Rot in heart...	S.....	No apparent cause.
		12	50.6	27.8	13.6	25	5	3	4,040	2,510	1,210	228	1	....	4	....	16	....	Rot and shake.	S.....	Rotten streaks.
		13	88.2	28.0	22.9	40	0	3	3,940	2,640	1,098	225	.....	.....	2	....	7	....	.....	T.....	No apparent cause.
		14	52.1	28.7	15.1	35	0	3	2,660	1,431	797	151	2	2	3	....	20	6	Rot streaks...	C. T.....	Small knot on upper face.
		15	48.0	29.0	13.9	40	0	3	2,040	1,594	976	115	9	....	3	1	15	2	.....do.....	T.....	Small knot 26 inches from center.
Average.....	.....	.....	57.6	29.1	16.6	35	2	.....	4,500	2,914	1,202	255									
Tamarack.....	4 x 10..	16	33.5	37.5	15.5	30	2	3	6,080	2,285	1,427	260	.....	.....	.....	.....	4	1	.....	C. T.....	No apparent cause.
		17	52.5	26.9	11.8	35	0	1	5,670	3,750	1,376	263	2	....	1	....	18	2	.....	C. T.....	Small knot on upper face.
		18	31.4	30.7	11.2	25	4	1	5,400	2,580	1,320	235	2	1	4	....	8	....	.....	C. T.....	Do.
		19	39.1	33.4	12.8	30	0	3	5,235	2,950	1,249	227	7	1	7	1	22	1	.....	T. C.....	Small corner knot 20 inches from center.
		20	43.5	30.1	12.5	30	1	3	5,150	3,425	1,502	248	4	1	5	1	36	....	.....	C. T.....	No apparent cause.
		21	38.0	31.0	11.6	20	0	3	5,050	2,905	1,415	209	7	....	5	2	20	3	.....	C. T.....	Small corner knot 28 inches from center.
		22	39.5	35.3	14.4	35	1	3	4,800	3,250	1,260	228	5	1	6	3	24	1	.....	T. C.....	Irregular grain at center.
		23	41.0	30.0	10.7	40	4	3	4,670	2,936	1,187	220	5	....	10	3	11	3	.....	C. T.....	No apparent cause.
		24	38.2	30.4	10.9	30	4	3	4,570	2,030	1,410	218	3	2	2	....	7	2	.....	C. T.....	2 small knots on upper face.
		25	80.8	28.4	12.2	35	0	3	4,410	2,480	1,220	206	....	1	2	5	15	3	.....	C. T.....	Large knot on upper face.
		26	33.8	30.1	8.0	35	0	1	4,035	2,075	860	187	4	....	5	8	16	8	.....	C. T.....	Large knot 6 inches from center.
		27	39.9	31.5	13.5	30	4	3	3,950	3,060	1,219	183	1	....	1	....	2	1	Cross grain....	T.....	Cross grain.
		28	65.7	28.7	9.7	25	0	1	3,750	2,560	1,165	175	4	1	1	....	9	2	.....	T.....	Large knot 6 inches from center.
		29	36.6	29.0	7.3	25	0	3	3,670	2,100	892	154	6	....	3	2	13	....	.....	C. T.....	Cross grain.
		30	39.5	33.4	8.4	25	0	3	2,722	2,300	1,071	127	3	2	9	....	27	....	Curly grain....	T.....	Large knot on lower face 14 inches from center.
Average.....	.....	.....	43.5	31.1	11.4	30	1	.....	4,611	2,712	1,238	209									

TABLE 14.—*Data on individual bending tests of green timbers of commercial sizes*—Continued.

Species.	Size.	Reference number.	Moisture.	Dry weight per cubic foot.	Rings per inch.	Summer wood.	Sap.	Cross-section classification.	Modulus of rupture per square inch.	Fiber stress at elastic limit per square inch.	Modulus of elasticity per square inch.	Horizontal shear per square inch.	Number of knots.						Other defects.	Manner of failure.	Cause of first failure.
													Vol. I.		Vol. II.		Vol. III.				
													Less than 1½ inches.	1½ inches and over.	Less than 1½ inches.	1½ inches and over.	Less than 1½ inches.	1½ inches and over.			
	Inches.		*P. ct.*	*Lbs.*		*P. ct.*	*P. ct.*		*Lbs.*	*Lbs.*	*1,000 Lbs.*	*Lbs.*									
Western hemlock..	8 x 16..	1	32.6	32.8	16.5	35	0	1	7,110	4,070	1,806	295	....	....	....	....	....	....	Checks.....	S.....	Apparently due to checks.
		2	37.3	32.4	27.0	55	0	1	7,050	4,580	1,788	291	....	....	9	....	13	....	.....do.....	C. T.....	Small corner knot 5 inches from center.
		3	64.2	28.7	10.3	45	0	1	6,990	4,220	1,550	291	1	....	....	....	12	1	.....	C. T.....	No apparent cause.
		4	34.0	27.3	26.5	25	0	1	6,360	3,880	1,721	264	4	....	....	....	13	1	Checks.....	C. S.....	Do.
		5	27.6	28.7	25.8	35	0	1	6,340	4,540	1,606	263	....	....	....	....	3	2	.....	C. S.....	Do.
		6	35.8	30.8	17.6	45	0	1	6,320	4,570	1,458	262	....	....	....	....	....	....	Checks.....	C. T.....	Do.
		7	33.4	28.4	13.2	30	0	1	6,075	3,750	1,461	252	1	2	3	1	15	2	.....do.....	C. S.....	Do.
		8	44.1	29.9	24.3	35	0	1	5,950	3,830	1,466	248	....	....	1	....	8	1	.....do.....	C. T.....	Do.
		9	39.0	27.5	21.5	45	0	1	5,935	3,560	1,385	246	....	....	....	....	10	1	.....do.....	C. T.....	Do.
		10	50.3	25.1	11.0	40	0	3	5,910	3,500	1,415	246	3	....	....	....	16	2	.....	C. T.....	Do.
		11	50.8	34.2	23.0	30	0	1	5,880	3,890	1,470	246	....	....	....	....	4	....	.....	C. T.....	Do.
		12	54.1	31.2	19.4	30	0	1	5,810	3,718	1,518	242	....	....	....	....	....	....	Checks.....	C. T.....	Do.
		13	33.0	26.1	21.0	30	0	1	5,705	3,600	1,236	236	....	....	8	....	6	1	.....	C. T.....	Do.
		14	40.0	27.9	12.8	38	0	1	5,630	3,200	1,487	366	....	....	....	1	....	....	.....	C. S.....	Large rotten knot 7 inches from center.
		15	27.2	27.1	21.2	35	0	3	5,615	3,680	1,408	234	2	1	4	1	22	7	.....	C. T.....	No apparent cause.
		16	55.9	26.1	6.2	32	0	1	5,580	3,690	1,494	363	2	....	4	....	4	1	.....	C. T.....	Do.
		17	58.5	32.6	16.3	35	0	1	5,537	3,900	1,535	231	....	....	....	....	3	....	Checks.....	C. T.....	Do.
		18	48.7	23.9	7.5	43	0	1	5,530	3,970	1,498	360	....	....	....	....	....	....	.....	C. T. S..	Do.
		19	39.6	26.1	12.6	45	0	3	5,515	3,645	1,575	230	....	....	....	1	17	2	Checks.....	C. T.....	Do.
		20	41.3	28.4	9.2	30	0	1	5,485	3,525	1,327	228	1	3	1	2	11	9	.....	C. T.....	Large knot on corner.
		21	58.0	27.6	10.7	52	0	1	5,450	4,160	1,623	355	....	2	2	1	4	6	.....	T. C.....	Large knot on bottom face 12 inches from center.
		22	29.1	27.8	22.6	30	0	1	5,440	3,160	1,491	227	....	....	3	1	10	2	Checks.....	C. S.....	No apparent cause.
		23	29.7	27.6	25.3	40	0	1	5,300	3,560	1,312	221	1	6	....	....	3	9	.....do.....	C. T. S..	Do.
		24	55.2	24.6	9.3	30	0	3	5,280	3,200	1,335	220	2	2	1	1	24	10	.....do.....	C. T.....	Do.
		25	28.4	26.6	27.2	40	0	1	5,235	2,875	1,419	217	1	....	1	1	24	3	.....	C. S.....	Do.
		26	28.0	25.5	14.7	25	0	1	5,115	3,595	1,385	212	1	2	2	....	13	1	Checks.....	C. T.....	Do.
		27	56.5	23.9	23.7	28	0	1	5,030	3,680	1,438	327	....	....	1	....	10	1	Rot spots.....	C. T.....	Due to rotten streaks.
		28	30.6	26.2	14.8	30	0	1	4,930	3,325	1,285	202	....	1	1	3	8	10	.....	C. T.....	No apparent cause.

* Sample of weathered coal.

† Sample from freshly cleared section in abandoned opening.

‡ Sample of fresh coal.

		29	59.0	24.7	7.8	37	0	3	4,840	3,190	1,466	315	2	1	2	2	11	3	Checks	C.S.	Do.
		30	53.5	24.7	7.7	25	0	3	4,780	3,190	1,424	311	1	....	3	2	16	4	.....do.	C.S.	Do.
		31	41.2	24.3	7.3	45	0	3	4,530	3,180	1,446	295	....	....	3	2	6	2	.....do.	C.S.	Do.
		32	58.7	26.3	6.1	53	0	1	4,500	3,270	1,496	291	2	....	....	....	1	....	Pitch pocket..	T.	Pitch pocket on lower face 36 inches from center.
		33	39.0	28.9	15.9	50	0	3	4,320	3,970	1,637	281	....	....	....	2	....	1	.....	S.	No apparent cause.
		34	32.2	27.5	12.4	67	0	1	4,270	3,160	1,095	178	....	....	....	....	....	....	.....	T.	Do.
		35	42.9	24.3	8.4	25	0	1	4,170	2,950	1,344	271	1	1	3	....	9	1	.....	T.C.	Large spike knot 24 inches from center.
		36	48.0	25.1	11.5	35	0	3	4,040	2,710	1,303	262	1	1	....	3	4	8	.....	T.C.	Large knot on lower face 43 inches from center.
		37	47.2	25.1	11.3	43	0	3	3,200	2,710	1,288	208	3	4	1	2	8	12	.....	T.	Large corner knot 13 inches from center.
		38	35.7	24.7	13.6	35	0	1	3,160	1,970	1,246	205	....	1	2	2	8	8	.....	T.C.	Large knot at center of bottom face.
		39	38.1	24.5	15.5	38	0	1	2,620	1,970	1,131	170	2	3	....	2	5	8	.....	T.	Large knot on bottom face 5 inches from center.
Average			42.5	27.3	15.6	38	0	.....	5,296	3,516	1,445	261									
Redwood	8 x 16..	1	89.9	22.4	29.4	44	0	1	6,610	4,900	1,188	446	....	....	1	1	9	1	.....	C.T.	No apparent cause.
		2	66.3	24.9	27.5	30	0	1	5,660	4,510	1,348	383	1	....	....	1	1	....	.....	C.T.	Do.
		3	116.1	20.8	20.3	36	0	3	5,180	4,600	1,010	348	1	....	4	5	14	11	.....	C.T.	Large knot on upper face.
		4	52.3	22.2	21.5	31	0	1	5,170	3,900	1,203	339	....	....	12	2	2	9	.....	C.T.	No apparent cause.
		5	57.9	25.9	28.0	28	0	1	4,650	4,590	1,296	315	3	....	3	1	12	1	.....	T.	Large corner knot 50 inches from center.
		6	157.7	19.8	16.5	35	0	1	4,620	4,110	967	307	1	....	....	....	1	....	.....	C.T.	No apparent cause.
		7	56.0	26.0	18.0	25	0	3	4,540	3,320	1,343	307	....	1	1	1	8	12	.....	S.	Do.
		8	62.2	23.1	17.0	38	0	3	4,440	3,420	1,265	297	....	....	3	3	5	7	.....	S.	Do.
		9	63.7	18.2	19.0	26	0	1	4,410	3,280	928	294	....	....	1	1	2	1	.....	C.T.	Do.
		10	167.4	21.2	8.5	45	0	1	4,140	3,080	688	272	....	....	....	....	10	....	.....	T.	Do.
		11	64.6	20.2	14.0	16	0	1	4,010	3,660	871	265	....	1	1	2	2	2	.....	C.T.	Large knots on upper face.
		12	74.2	22.0	27.3	36	0	1	4,000	3,610	607	268	....	....	....	....	2	2	.....	T.	No apparent cause.
		13	121.0	23.5	8.5	31	0	1	3,530	3,410	861	229	....	2	....	1	6	6	.....	T.	Do.
		14	61.8	20.9	22.6	33	0	2	1,930	1,880	645	129	2	1	....	4	7	7	.....	T.	Irregular grain caused by knot.
Average			86.5	22.2	19.9	32	0	.....	4,492	3,734	1,016	300									
Redwood	6 x 12..	15	65.9	28.5	36.0	43	0	3	5,970	4,290	1,285	303	....	1	1	5	19	15	.....	C.T.S.	No apparent cause.
		16	143.2	22.5	17.3	34	0	1	5,850	5,130	1,345	294	....	....	....	....	....	....	.....	C.T.	Do.
		17	91.1	23.0	11.0	36	0	2	5,520	4,340	1,148	279	....	....	1	....	1	....	.....	C.T.	Do.
		18	64.0	24.5	10.0	23	0	2	5,460	4,890	1,283	278	1	1	1	1	5	2	.....	C.T.	Do.
		19	75.1	22.0	22.0	31	0	1	4,860	4,610	1,057	245	....	....	....	....	....	....	.....	C.T.	Do.
		20	214.8	20.3	8.9	28	0	1	4,820	4,210	1,131	236	....	....	....	....	2	....	.....	C.T.	Do.
		21	59.6	28.1	24.3	36	0	1	4,710	3,770	1,572	239	3	....	2	2	14	8	.....	C.T.	Do.
		22	69.8	21.5	39.7	27	0	1	4,580	3,710	1,128	232	....	....	....	2	6	2	.....	T.	No apparent cause; brash failure.
		23	96.9	22.8	7.5	20	0	1	4,300	3,550	566	215	....	....	....	....	4	....	.....	T.S.	No apparent cause.

TABLE 14.—*Data on individual bending tests of green timbers of commercial sizes*—Continued.

Species.	Size.	Reference number.	Moisture.	Dry weight per cubic foot.	Rings per inch.	Summer wood.	Sap.	Cross-section classification.	Modulus of rupture per square inch.	Fiber stress at elastic limit per square inch.	Modulus of elasticity per square inch.	Horizontal shear per square inch.	Number of knots.						Other defects.	Manner of failure.	Cause of first failure.
													Vol. I.		Vol. II.		Vol. III.				
													Less than 1½ inches.	1½ inches and over.	Less than 1½ inches.	1½ inches and over.	Less than 1½ inches.	1½ inches and over.			
	Inches.		*P. ct.*	*Lbs.*		*P. ct.*	*P. ct.*		*Lbs.*	*Lbs.*	*1,000 lbs.*	*Lbs.*									
Redwood	6 x 12	24	84.8	21.8	19.5	37	0	2	4,080	2,840	672	207	....	....	....	....	....	....		T	No apparent cause; brash failure.
		25	82.9	22.1	18.7	32	0	3	3,510	3,410	1,084	177	....	....	9	1	20	11		T. C.	No apparent cause.
		26	60.0	21.0	16.0	14	0	1	2,990	2,650	746	148	....	....	....	....	3	15		T	Wavy grain 15 inches from center.
		27	65.5	18.0	9.9	12	0	1	2,970	2,940	933	145	....	2	....	1	1	3		T	Large knot 40 inches from center.
		28	48.0	20.7	9.0	14	0	4	2,700	2,680	998	135	1	1	9	3	24	17		T. S.	Do.
Average			87.3	22.6	17.8	28	0	.....	4,451	3,787	1,068	224									
Redwood	7 x 9	29	48.2	30.6	24.8	41	0	1	9,760	6,750	2,222	407	....	....	....	....	....	2		C. T. S.	No apparent cause.
		30	51.7	21.5	20.0	33	0	3	7,180	5,530	1,560	267	9	....	3	3	36	5		C. T.	Do.
		31	94.3	28.3	20.3	36	7	1	6,920	5,710	1,432	260	....	....	2	....	....	....		C. T.	Do.
		32	75.5	25.5	14.3	28	0	3	6,880	5,360	1,377	253	....	....	1	2	6	6		C. T.	Do.
		33	57.1	22.3	28.0	14	0	1	6,100	4,820	1,306	226	....	....	....	....	2	....	Curl	C. T.	Do.
		34	66.3	22.6	19.5	30	0	3	5,750	4,000	1,070	212	2	....	6	5	25	3		C. T.	Large knot on top face near center.
		35	128.3	25.6	27.8	39	0	1	4,900	4,320	1,354	186	....	....	....	....	....	....		C. T.	No apparent cause.
		36	61.8	21.8	7.0	12	0	1	4,630	4,380	1,106	171	2	....	4	....	31	7		C. T.	Do.
		37	216.9	19.8	8.0	15	0	1	4,300	4,000	1,075	156	....	....	....	....	3	1		C. T.	Do.
		38	50.3	22.5	12.0	13	0	3	3,830	3,780	1,143	141	5	1	2	4	30	16		T	Large knot on bottom face 53 inches from center.
		39	52.6	21.7	15.0	22	0	1	3,710	3,550	1,172	136	....	....	....	....	1	2		T	Cross grain.
		40	67.1	21.0	16.0	18	0	1	3,710	3,400	714	136	1	2	....	....	3	2		T	Large knot in bottom face 50 inches from center.
		41	69.3	21.1	7.0	13	0	1	3,510	3,500	1,290	132	....	1	2	2	3	6		T	Cross grain.
		42	77.6	16.9	14.5	21	0	1	2,730	2,670	759	103	....	1	....	....	1	2		T	Irregular grain.
Average			79.8	23.2	16.7	24	.5	.....	5,279	4,412	1,256	199									

Redwood	3 x 14	43	64.5	26.0	22.8	8	0	1	6,410	4,560	1,383	373	1				13	7		C. T.	No apparent cause.
		44	51.2	27.3	31.4	32	0	1	6,000	4,430	1,312	353			1	1	24	5	Shake	C. S.	Do.
		45	58.8	23.5	32.8	14	0	1	5,730	3,950	1,258	339			2	1	1	3		C. T.	Do.
		46	130.8	23.2	42.1	36	0	1	4,730	3,560	976	276			2	1	11	5		C. T.	Small knot on top face 20 inches from center.
		47	98.2	26.8	17.5	16	0	1	4,570	3,780	855	269					1			C. T.	No apparent cause.
		48	70.4	19.9	15.5	10	0	2	4,180	3,630	994	239	1	2		1	5	6		C. T.	Do.
		49	132.8	20.0	10.0	15	0	1	4,030	3,550	1,000	235			1	2	4	5		S.	Do.
		50	63.2	17.6	29.5	8	0	1	4,000	2,860	697	231					2			C. T.	Do.
		51	66.8	23.3	19.5	31	0	1	3,900	2,960	816	227			2		4	3		T.	Do.
		52	139.2	21.5	38.1	37	0	1	3,890	3,610	982	228	1		4		73	3	Check	S.	Do.
		53	74.2	17.1	15.7	25	0	1	3,620	2,870	696	211					1	1		C. T. S.	Do.
		54	79.3	21.1	25.5	35	0	1	3,440	2,610	646	200					1	1		C. T.	Do.
		55	89.6	21.7	7.8	12	0	1	2,230	2,210	702	128					3	6		S.	Do.
Average			86.1	22.2	23.7	21	0		4,364	3,506	947	255									
Redwood	2 x 12	56	38.5	25.5	31.5	9	0	1	5,710	5,270	1,602	279					6			C.	Do.
		57	54.8	23.0	15.0	19	0	1	4,010	3,250	1,196	203		1		2	14	12		C. T.	Do.
		58	41.1	20.8	16.3	32	0	2	3,900	2,990	983	198			2	2	1	4		C. S.	Large knot on top face 15 inches from center.
		59	88.6	25.5	17.3	39	0	2	3,810	2,500	1,128	191	1		3					T.	No apparent cause—brash failure.
		60	124.3	17.2	10.5	12	0	1	3,790	3,150	1,042	188					29			C.	Do.
		61	47.6	22.1	31.6	27	0	3	3,790	2,920	891	190			2	3	12	7		C. T.	Large knot on top face 15 inches from center.
		62	90.2	18.8	11.1	19	0	2	3,770	2,420	1,109	189	5	1	3	3	1	1		C. T.	Large corner knot 22 inches from center.
		63	48.9	27.6	34.2	29	0	1	3,680	2,910	537	186					1			T.	No apparent cause—brash failure.
		64	77.7	20.0	7.0	12	0	2	3,360	3,270	1,037	165		1		2	6	3		C. T.	No apparent cause.
		65	145.9	30.5	7.0	32	0	2	3,190	3,040	839	152					3	4		T.	No apparent cause—brash failure.
		66	52.9	22.1	20.8	14	0	1	3,180	3,060	1,337	156	1	2	6	1	9	9		T.	Large corner knot 30 inches from center.
		67	40.7	23.7	20.7	30	0	1	2,850	2,420	919	145	1	4	1	3	13	15		T.	Large corner knot 21 inches from center.
Average			70.9	23.1	18.6	23	0		3,753	3,100	1,052	187									
Redwood	2 x 10	68	39.1	25.6	22.5	14	0	1	6,510	5,170	1,584	273					2			C. T.	No apparent cause.
		69	81.5	24.6	22.0	10	0	2	5,200	4,390	1,304	212					20			C. T.	Do.
		70	54.3	27.6	32.3	32	0	2	5,190	4,090	1,456	217			1	2	3	1		C. T.	Large knot on top face 28 inches from center.
		71	90.8	25.1	10.0	15	0	2	4,520	3,860	982	189			2		6	2		C. T.	No apparent cause.
		72	69.0	22.3	15.0	14	0	1	4,350	3,690	1,333	177	1				6	1		C. T.	Do.
		73	31.2	26.5	28.8	36	0	2	4,290	3,020	571	178					53			C.	Do.
		74	38.6	20.7	26.5	37	0	1	4,080	3,070	1,019	174					8	8		S.	Checks.
		75	33.4	17.8	33.8	31	0	1	3,460	2,220	671	145					34		Shake	C.	No apparent cause.
		76	27.6	21.8	18.3	30	0	2	3,380	3,260	1,121	140			6	2	9	4		S.	Checks.
		77	28.8	24.2	18.0	21	0	1	3,360	1,940	1,645	139	2	1	3		15		Checks	S.	Do.
		78	94.2	22.8	7.0	25	0	1	3,150	2,900	671	128					2	4		T.	Irregular grain.

TABLE 14.—*Data on individual bending tests of green timbers of commercial sizes*—Continued.

Species.	Size.	Reference number.	Moisture.	Dry weight per cubic foot.	Rings per inch.	Summer wood.	Sap.	Cross-section classification.	Modulus of rupture per square inch.	Fiber stress at elastic limit per square inch.	Modulus of elasticity per square inch.	Horizontal shear per square inch.	Number of knots.						Other defects.	Manner of failure.	Cause of first failure.
													Vol. I.		Vol. II.		Vol. III.				
													Less than 1½ inches.	1½ inches and over.	Less than 1½ inches.	1½ inches and over.	Less than 1½ inches.	1½ inches and over.			
	Inches.		*P. ct.*	*Lbs.*		*P. ct.*	*P. ct.*		*Lbs.*	*Lbs.*	*1,000 lbs.*	*Lbs.*									
Redwood	2 x 10	79	72.1	21.1	15.0	17	0	2	2,940	2,550	947	121				1	3	3		C. T.	No apparent cause.
		80	64.8	20.7	11.0	12	0	1	2,600	2,550	1,088	105	1	2	1	1	3	14		T.	Large corner knot 48 inches from center.
Average			55.8	23.1	20.0	23	0		4,079	3,285	1,107	169									
Redwood	2 x 8	81	41.7	24.8	35.0	39	0	1	6,530	4,100	1,364	222			3		10	2		C. T.	Large corner knot 36 inches from center.
		82	32.6	25.4	18.3	42	0	2	5,840	4,450	1,557	198			10	1	10	2		C. T.	Small corner knot at center.
		83	49.7	24.8	23.0	36	0	1	5,430	4,370	1,124	182					2	1		C. T.	No apparent cause.
		84	27.5	21.7	27.1	34	0	2	4,480	2,930	1,095	139			4	5	5	4		T. C.	Bruise on lower face at center.
		85	117.3	23.6	34.4	50	0	2	4,380	3,360	1,345	147					3	2		C.	Small corner knot 10 inches from center.
		86	123.0	23.5	28.0	11	0	2	4,290	3,270	1,133	135					11			C. T.	No apparent cause.
		87	41.9	18.4	16.0	28	0	1	3,860	2,740	718	129						2		C. T.	Do.
		88	79.0	19.9	5.5	9	0	2	3,710	2,260	1,090	124			5	1	1	7		C. T.	Do.
		89	58.1	31.2	26.0	23	0	1	3,560	3,060	1,172	120					7	1		T.	Do.
		90	63.8	18.0	20.0	11	0	2	3,520	2,880	751	113					1			T.	Do.
		91	59.6	27.3	31.5	15	0	2	3,030	2,040	1,502	100	2	1	2	2	12	3		T.	Large corner knot 48 inches from center.
		92	70.6	16.8	7.0	8	0	1	2,700	2,280	971	87		1		1		1		C. T.	No apparent cause.
		93	64.4	22.3	7.5	10	0	1	1,483	1,111	1,006	47	1	1	1	3	15	7		T.	Small corner knot 6 inches from center.
Average			63.8	22.9	21.5	24	0		4,063	2,989	1,141	134									
Norway pine	6 x 12	1	46.0	26.5	13.0	20		3	4,550	2,530	1,328	255	1		6		9			C.	Due to small knot in upper face.
		2	48.2	25.7	32.4	30		3	4,465	2,938	1,190	249					11		Heart checks.	S.	Due to heart checks
		3	52.4	23.6	12.5	20		3	4,350	2,910	1,105	243	4		1	1	15	1	Wind shake.	C. T.	No apparent cause.

		4	39.8	27.3	10.8	20	.....	3	4,065	2,670	1,030	231	3	....	3	2	18	5	.....	C. T.....	Large knot on corner 10 inches from center.
		5	41.9	26.2	13.5	20	.....	3	3,680	1,995	1,015	205	1	2	5	5	14	18	.....	C. T.....	Large knot on upper face 8 inches from center.
		6	85.8	21.5	12.9	20	42	3	3,330	2,130	901	187	1	4	5	6	20	13	.....	C. T.....	Large knot on corner 16 inches from center.
		7	60.2	22.2	11.2	20	36	3	3,550	2,319	924	200	1	2	1	3	7	16	.....	C. T.....	Large spike knot 8 inches from center.
		8	43.6	26.9	11.9	20	.....	3	3,540	2,890	1,050	204	3	2	2	3	19	9	.....	T. C.....	Large knot on lower face 42 inches from center.
		9	35.3	26.3	6.7	15	.....	3	3,495	1,600	866	196	6	2	5	2	7	8	.....	C. T.....	Small knot on upper face.
		10	44.7	27.7	9.3	20	.....	3	3,260	2,550	1,143	184	2	4	2	1	13	9	Heart checks..	S.....	Due to heart checks.
		11	75.0	23.1	10.7	15	32	3	3,155	1,840	906	176	5	4	1	4	21	17	.....	C. T.....	Small knot on upper face 5 inches from center.
		12	41.0	24.5	9.9	.....	.....	3	3,148	2,045	864	180	....	2	6	3	5	10	.....	C. T.....	Large knot on upper face 11 inches from center.
		13	44.8	24.5	10.7	15	15	3	3,145	2,140	857	177	6	3	2	4	18	11	.....	C. T.....	Large knot on upper face 16 inches from center.
		14	43.3	23.0	9.8	15	.....	3	3,030	2,075	808	170	....	3	3	1	12	6	.....	T. C.....	Large knot on lower face 8 inches from center.
		15	53.0	25.5	12.5	20	.....	3	2,810	1,950	812	158	2	5	2	1	15	7	.....	C. T.....	No apparent cause.
Average.....	.....	.....	50.3	25.0	12.5	19	31	.....	3,572	2,305	987	201									
Norway pine.....	4 x 12..	16	42.1	28.1	24.2	25	.....	3	5,560	2,748	1,449	313	.....	.....	.....	.....	6	6	Heart checks..	C. S.....	Do.
		17	51.0	28.6	13.2	30	.....	1	5,250	3,280	1,395	296	.....	.....	.....	.....	5	.....	.....	C. T.....	Do.
		18	47.4	27.4	19.2	20	15	3	4,950	3,295	1,490	318	3	.....	.....	.....	27	.....	.....	C. T.....	Do.
		19	58.8	26.0	19.1	20	.....	3	4,680	3,280	1,261	264	.....	.....	1	1	14	.....	.....	C. T.....	Do.
		20	47.9	29.0	15.8	25	.....	3	4,670	3,915	1,375	265	.....	.....	.....	.....	19	4	.....	S.....	Do.
		21	54.4	25.9	11.9	25	.....	3	4,600	2,692	1,455	259	2	.....	.....	.....	12	.....	.....	C. S.....	Do.
		22	64.0	25.0	21.1	25	.....	1	4,590	3,000	1,300	256	.....	.....	.....	2	7	1	.....	C. T.....	Do.
		23	36.5	25.6	13.6	20	.....	3	4,150	2,640	1,071	234	6	....	2	1	29	1	.....	C. T.....	Small knot on upper face.
		24	51.7	25.7	11.2	15	20	3	4,140	2,680	1,268	261	1	.....	2	.....	15	1	.....	C. T.....	Small knot on upper face 6 inches from center.
		25	41.8	23.5	17.4	20	.....	3	4,000	.....	.....	227	2	.....	1	.....	22	1	Heart checks..	C. S.....	Small knot on upper face.
		26	33.2	25.5	8.0	15	.....	3	3,745	2,505	1,055	209	1	3	3	.....	14	5	.....	C. T.....	Do.
		27	36.5	24.3	6.7	15	0	3	3,620	2,384	1,000	203	2	2	3	1	12	8	.....	C. T.....	No apparent cause.
		28	56.0	22.5	10.4	25	25	3	3,525	2,180	1,152	222	4	.....	4	1	13	2	.....	C. T.....	Small knot on upper face.
		29	52.0	23.8	9.9	15	.....	3	3,520	2,320	996	198	3	.....	1	.....	23	2	.....	C. T.....	Small knot on upper face 9 inches from center.
		30	56.0	24.6	12.2	15	.....	3	3,390	1,981	1,666	189	2	.....	3	1	20	.....	.....	C. T.....	Small knot on upper face 4 inches from center.
		31	59.5	23.7	13.5	20	30	3	3,360	2,175	1,025	216	.....	.....	.....	3	13	11	.....	C.....	Small knot on upper face 14 inches from center.
		32	31.3	24.9	8.2	15	.....	3	3,350	1,823	1,411	189	3	1	3	.....	19	6	.....	C. T.....	No apparent cause.
		33	41.6	23.1	29.2	30	.....	1	2,820	2,110	961	160	.....	.....	1	.....	14	.....	Cross grain....	T.....	Cross grain.
Average.....	.....	.....	47.9	25.4	14.7	21	22	.....	4,107	2,648	1,255	238									
Norway pine.....	4 x 10..	34	43.7	27.5	15.9	35	40	1	5,625	3,700	1,625	266	.....	.....	.....	1	10	1	.....	C. T.....	No apparent cause.
		35	41.1	25.8	13.2	15	20	3	5,290	2,960	1,490	256	.....	.....	1	.....	2	.....	.....	C. T.....	Do.
		36	29.5	28.0	20.8	25	.....	3	5,140	3,910	1,445	239	.....	.....	.....	.....	4	.....	.....	C. T.....	Do.

TABLE 14.—*Data on individual bending tests of green timbers of commercial sizes*—Continued.

Species.	Size.	Reference number.	Moisture.	Dry weight per cubic foot.	Rings per inch.	Summer wood.	Sap.	Cross-section classification.	Modulus of rupture per square inch.	Fiber stress at elastic limit per square inch.	Modulus of elasticity per square inch.	Horizontal shear per square inch.	Number of knots. Vol. I. Less than 1½ inches.	Vol. I. 1½ inches and over.	Vol. II. Less than 1½ inches.	Vol. II. 1½ inches and over.	Vol. III. Less than 1½ inches.	Vol. III. 1½ inches and over.	Other defects.	Manner of failure.	Cause of first failure.
	Inches.		*P. ct.*	*Lbs.*		*P. ct.*	*P. ct.*		*Lbs.*	*Lbs.*	*1,000 lbs.*	*Lbs.*									
Norway pine	4x10..	37	38.0	29.8	18.5	35	25	3	4,930	2,465	1,511	234	....	....	....	....	9	1	.....	T.....	No apparent cause.
		38	59.0	28.2	15.8	20	.....	3	4,630	3,000	1,556	220	2	....	1	1	8	....	.....	C. T.....	Small knot on upper face 24 inches from center.
		39	72.6	26.4	13.7	20	.....	3	4,620	3,100	1,328	216	1	....	2	....	7	3	.....	C.....	No apparent cause.
		40	54.2	22.3	12.5	15	.....	3	4,190	2,760	1,268	193	2	....	3	....	9	....	.....	C. T.....	Do.
		41	65.8	27.3	11.0	20	.....	3	4,040	2,570	1,700	190	....	2	1	....	12	17	.....	T. C.....	Large knot on bottom face 6 inches from center.
		42	34.2	22.1	10.2	25	.....	3	4,010	2,455	1,088	190	2	1	1	1	13	1	.....	T.....	Large knot on bottom face 33 inches from center.
		43	39.5	28.0	12.5	20	20	3	4,010	2,875	1,441	188	1	1	1	1	9	2	.....	C. T.....	Large knot on upper face 14 inches from center.
		44	49.2	26.0	9.0	30	.....	1	3,690	2,410	1,074	176	....	1	1	....	1	....	.....	T. C.....	Large knot 13 inches from center.
		45	39.0	24.2	11.2	15	.....	3	3,575	2,305	1,145	169	3	....	1	....	22	....	.....	C. T	No apparent cause.
		46	49.5	24.8	13.3	20	.....	3	3,560	2,312	1,147	158	2	1	4	....	12	4	.....	C. T.....	Do.
		47	47.1	27.0	11.0	15	0	3	3,470	1,689	1,221	162	4	1	4	1	22	2	.....	T. C. T..	Large spike knot on edge 8 inches from center.
		48	36.9	23.2	15.3	15	.....	3	3,290	2,125	898	155	3	2	1	3	22	3	.....	C. T.....	No apparent cause.
		49	32.6	23.0	8.8	20	20	3	3,215	2,150	960	149	....	....	....	6	7	4	.....	T.....	No apparent cause—brash failure.
Average			45.7	25.8	13.3	22	21	.....	4,205	2,674	1,306	198									
Red spruce	2x10..	1	31.9	23.9	17.0	28	.....	3	4,700	3,480	1,338	236	9	....	5	1	26	5	.....	C. T.....	No apparent cause.
		2	31.8	24.6	22.5	24	.....	3	4,460	2,720	1,316	231	....	....	3	1	15	2	.....	C.....	Do.
		3	32.1	23.5	27.0	24	.....	3	4,450	2,640	1,408	226	....	....	2	....	16	....	.....	C.....	Do.
		4	30.0	26.8	26.0	29	.....	3	4,110	2,340	1,168	205	1	....	9	....	21	5	.....	C. T.....	Do.
		5	32.6	27.1	20.0	20	.....	3	3,920	2,750	1,082	202	1	....	3	1	27	6	.....	T. C. T..	Large corner knot 30 inches from center.
		6	35.8	25.3	21.0	27	.....	3	3,930	2,290	1,214	198	2	....	10	1	29	4	.....	C.....	Small corner knot 18 inches from center.

		7	31.0	23.7	14.0	20	.....	3	3,910	2,660	1,257	198	6	....	9	1	32	5	.....	C.....	No apparent cause.
		8	32.0	26.6	27.0	20	.....	4	3,590	2,410	1,275	183	....	....	18	2	8	....	.....	C. T.....	Do.
		9	26.7	28.6	24.0	20	.....	3	3,520	2,590	1,390	180	3	....	9	....	14	3	.....	C. T.....	Do.
		10	33.9	24.8	23.0	20	.....	3	2,920	2,070	1,046	149	3	....	6	3	37	4	.....	C. T.....	Do.
		11	.....	.....	21.0	20	.....	3	2,900	1,886	1,133	147	7	....	....	....	31	1	.....	C. T.....	Do.
		12	32.5	24.8	20.0	24	.....	3	2,880	1,472	870	148	3	2	2	2	21	7	.....	C. T.....	Do.
		13	41.1	26.3	23.5	20	.....	3	2,350	2,230	1,000	119	....	....	12	2	16	1	.....	T.....	Cross grain.
		14	31.4	25.3	20.0	21	.....	3	2,280	1,978	1,029	116	2	2	2	....	29	1	.....	T.....	Do.
Average....	.....	.....	32.5	25.5	21.9	23	.....	.....	3,566	2,394	1,180	181									
White spruce.....	2 x 10..	1	30.8	22.9	16.5	26	.....	3	4,250	2,300	1,216	213	....	1	4	1	41	14	.....	C.....	No apparent cause.
		2	39.0	25.0	17.0	39	.....	3	4,030	2,830	1,226	205	9	....	7	....	28	....	.....	C. T.....	Do.
		3	32.9	22.3	14.5	22	.....	3	3,950	3,000	1,422	200	2	....	9	....	51	5	.....	C.....	Do.
		4	37.1	26.6	13.0	32	.....	3	3,750	2,020	1,257	186	6	....	6	....	12	1	.....	C. S.....	Do.
		5	70.0	19.0	9.0	13	.....	3	3,680	2,520	1,204	184	3	1	3	....	14	2	.....	C. T.....	Do.
		6	34.4	21.2	6.0	10	.....	3	3,590	2,450	1,232	183	3	2	1	3	27	5	.....	C. T.....	Do.
		7	65.0	18.8	10.0	14	.....	3	3,480	2,630	1,146	178	5	....	2	....	21	....	.....	T. C.....	Do.
		8	32.8	22.1	10.0	16	.....	3	3,470	2,440	1,085	177	5	2	5	2	26	5	.....	C. T.....	Do.
		9	27.5	21.7	6.0	16	.....	3	3,280	1,872	1,112	167	3	3	2	2	19	9	.....	C. T.....	Do.
		10	27.9	21.2	7.0	16	.....	3	2,970	2,060	1,222	152	5	1	4	3	26	6	.....	T.....	Cross grain.
		11	51.6	18.8	7.0	14	.....	3	2,930	2,330	948	147	5	....	2	....	20	1	.....	C. T.....	No apparent cause.
		12	41.4	20.7	7.5	14	.....	3	2,820	1,907	876	143	4	1	4	2	18	5	.....	C. T.....	Do.
		13	30.5	20.7	6.5	12	.....	3	2,790	1,908	925	142	8	....	8	4	20	6	.....	T. C. T..	Do.
		14	43.3	19.7	6.0	15	.....	3	2,580	1,715	793	131	6	3	2	3	26	7	.....	C. T.....	Do.
		15	41.0	21.1	7.0	16	.....	3	2,540	2,310	787	129	2	1	4	3	30	3	.....	T.....	Large corner knot 6 inches from center.
		16	46.0	19.3	6.0	17	.....	3	2,490	1,527	844	125	3	2	5	2	16	8	.....	C. T.....	Large corner knot 15 inches from center.
Average....	.....	.....	40.7	21.3	9.3	18	.....	.....	3,288	2,239	1,081	166									

TABLE 15.—*Data on individual bending tests of air-seasoned timbers of commercial sizes.*

Species.	Size.	Reference number.	Months seasoned.	Moisture.	Dry weight per cubic foot.	Rings per inch.	Summer wood.	Sap.	Cross-section classification.	Modulus of rupture per square inch.	Fiber stress at elastic limit per square inch.	Modulus of elasticity per square inch.	Horizontal shear.	Number of knots.						Other defects.	Manner of failure.[1]	Cause of first failure.
														Vol. I.		Vol. II.		Vol. III.				
														Less than 1½ inches.	1½ inches and over.	Less than 1½ inches.	1½ inches and over.	Less than 1½ inches.	1½ inches and over.			
	Inches.			*P. ct.*	*Lbs.*		*P. ct.*	*P. ct.*		*Lbs.*	*Lbs.*	*1,000 lbs.*										
Longleaf pine..	8 x 16..	1	.....	22.0	44.2	11.6	.....	0	3	6,870	3,650	1,750	467	....	....	....	....	....	....	Checks.....	T.....	No apparent cause.
		2	.....	23.0	39.9	14.5	.....	0	3	5,010	2,780	1,664	338	....	....	....	....	....	....	.....do.....	S.....	Apparently influenced by checks.
		3	.....	22.0	39.9	14.7	.....	6	3	3,930	3,740	1,872	261	....	....	....	....	....	....	.....do.....	S. T. C..	Do.
		4	.....	23.0	39.9	13.5	.....	2	3	3,520	.....	1,810	236	....	....	....	....	....	....	.....do.....	S.....	Do.
		5	.....	21.0	42.4	25.7	.....	0	3	2,040	.....	1,640	137	....	....	....	....	....	....	.....do.....	S.....	Do.
Average..	.....	.....	.....	22.2	41.3	16.0	.....	1.6	.....	4,274	3,390	1,747	288									
Longleaf pine..	6 x 16..	6	15	23.4	37.4	17.1	.....	7	1	6,610	3,470	1,501	388	....	....	....	....	....	....	.....do.....	S.....	Do.
Do	6 x 10..	7	15	18.1	36.2	10.0	.....	0	3	8,640	4,620	1,865	238	....	....	....	....	....	....	.....	C. T....	No apparent cause.
		8	15	20.0	32.4	7.6	.....	0	3	7,120	4,500	1,580	190	....	....	....	....	....	....	.....	C. T....	Do.
Average..	.....	.....	.....	19.0	34.3	8.8	.....	0	.....	7,880	4,560	1,722	214									
Longleaf pine..	4 x 11..	9	15	18.4	39.3	23.9	.....	8	1	8,000	3,078	1,660	251	....	....	....	....	....	....	.....	T.....	Do.
Do	6 x 8...	10	15	19.5	38.7	6.8	.....	2	3	10,020	4,970	2,010	202	....	....	....	....	....	....	Checks.....	C. T....	Do.
		11	15	19.3	34.9	16.0	.....	30	3	9,070	4,510	1,950	186	....	....	....	....	....	....	.....do.....	C. T....	Do.
		12	15	17.3	35.6	9.0	.....	0	3	8,940	4,170	1,765	233	....	....	1	....	8	....	.....	T.....	Irregular grain 11 inches from center.
		13	15	19.8	38.6	16.0	.....	3	3	7,985	4,640	1,510	168	2	....	2	1	8	3	.....	C. T....	Small knot on top face 9 inches from center.
		14	15	20.3	36.8	17.3	.....	2	3	6,620	3,540	1,275	135	1	2	3	....	2	....	.....	T.....	Large corner knot 30 inches from center.
		15	15	23.9	41.8	17.0	.....	2	3	6,540	3,530	1,291	136	1	....	....	2	1	5	.....	C. T....	Large knot on top face 6 inches from center.
Average..	.....	.....	.....	20.0	37.7	13.7	.....	6	.....	8,196	4,227	1,634	177									
Douglas fir.....	8 x 16..	1	27	17.9	30.6	20.4	25	0	1	8,750	6,310	1,954	346	....	....	....	....	1	....	Checks.....	C. S....	No apparent cause.
		2	8	26.5	35.4	17.7	36	0	2	8,730	5,270	2,203	345	....	....	....	....	....	....	.....do.....	C. S....	Do.

3	15	16.8	30.6	15.6	35	0	1	8,590	6,830	1,735	357	1		1		3	3	do	C. S.	Do.
4	33	17.7	31.7	12.0	25	0	3	8,500	6,570	1,550	373				3		1		C. T.	Do.
5	25	18.7	27.0	12.7	18	0	3	8,480	5,070	1,653	364			2					C. S.	Do.
6	8	26.1	33.7	12.4	33	0	2	8,390	5,340	1,935	335			1		9			C. S.	Do.
7	13	21.0	34.1	14.4	33	0	1	8,190	5,470	1,981	325			1					C. S.	Do.
8	15	16.8	31.1	12.6	32	0	3	8,110	6,120	1,670	339		3	2		4	4	Checks	T. C.	Do.
9	18	21.3	30.8	15.5	29	0	1	8,000	4,940	1,843	343					12			C. T.	Do.
10	26	13.5	33.8	15.8	31	0	2	7,990	5,550	1,674	318	4				1			T.	Small corner knot 22 inches from center.
11	13	19.8	31.9	18.6	29	0	1	7,960	6,360	2,016	314					9			C. S.	No apparent cause.
12	18	20.7	26.7	10.3	21	0	3	7,930	5,030	1,704	340	3				21			C. S.	Do.
13	16	19.7	28.4	17.4	23	0	1	7,850	5,710	1,839	334	1				9			C. S.	Do.
14	18	19.8	27.0	28.7	28	0	1	7,790	5,970	1,702	333					10			C. S.	Do.
15	19	20.6	27.2	30.3	29	0	1	7,700	4,670	1,450	332					9			C. T.	Do.
16	14	20.4	26.4	8.0	18	0	3	7,620	5,210	1,705	327	2				16	2		C. T.	Do.
17	18	19.2	25.1	10.7	28	0	1	7,620	3,840	1,410	328			5		16	1	Checks	C. T. S.	Do.
18	25	20.0	27.9	7.3	22	0	4	7,480	5,120	1,706	320	3		2		1			C. T.	Do.
19	15	16.7	30.6	11.6	39	0	1	7,410	6,210	1,570	308					5	1	Checks	T.	Irregular grain.
20	25	19.4	28.6	18.5	26	0	1	7,410	5,360	1,880	317			2		19		do	C. S.	No apparent cause.
21	26	17.6	32.2	26.3	30	0	1	7,380	4,720	1,965	292					3		do	C. S.	Do.
22	3	30.5	29.0	6.8	30	0	1	7,380	4,260	1,305	318								C. T.	Do.
23	14	25.2	25.1	24.4	31	0	1	7,360	5,350	1,795	293			1				Checks	C. S.	Do.
24	7	24.5	27.8	24.0		0	1	7,290	4,950	1,520	395					11			C. S.	Do.
25	25	16.9	26.7	12.5	20	0	4	7,240	4,090	1,712	293	1		2		29		Checks	C. T.	Do.
26	13	19.0	26.7	7.8	18	0	3	7,220	4,780	1,735	287	1		3		21	1	do	C. S.	Do.
27	7	23.0	27.1	27.3	27	0	1	7,210	4,610	1,544	310					8		do	C. S.	Do.
28	7	27.0	28.2	23.0		0	1	7,130	4,470	1,710	390			1		12			C. T.	Do.
29	19	18.5	27.7	28.0	28	0	1	7,100	5,100	1,472	208					2	4	Checks	S.	Do.
30	15	15.4	25.8	10.3	24	0	3	7,090	5,530	1,890	296	2	3	2	5	11	2		C. S.	Do.
31	20	18.1	26.8	29.2	29	0	1	7,090	4,830	1,592	283						1	Checks	C. S.	Do.
32	18	25.0	28.3	23.4	31	0	1	7,060	5,370	1,976	283					7			C. T.	Do.
33	20	23.6	26.2	21.2	33	0	1	7,050	4,340	1,471	299					8	1		C. T.	Do.
34	6	23.3	27.9	4.0	26	0	1	7,040	5,470	1,470	281	2		1		16	5	Checks	C. T.	Do.
35	15	17.3	28.0	9.8	39	0	1	7,040	4,990	1,715	293			1	1	5	6	do	T. S.	Irregular grain.
36	8	23.8	28.6	17.5	24	0	1	6,990	5,050	1,930	278			2		15		do	C. S.	No apparent cause.
37	18	19.0	24.5	7.3	24	0	3	6,980	4,610	1,552	298	2		5		26	1	do	C. T.	Do.
38	19	21.5	27.2	12.9	25	0	3	6,950	4,640	1,590	300			3		22			C. T.	Do.
39	18	21.9	27.8	7.4	24	0	3	6,900	5,610	1,740	298			2		35			C. S.	Do.
40	20	22.7	29.2	17.8	24	0	1	6,890	4,830	1,765	297	1		1	1	13	1		C. S. T.	Do.
41	24	15.1	30.6	15.9	25	0	1	6,880	4,920	1,780	294			2		1			C. S.	Do.
42	5	23.5	25.9	4.6	21	0	3	6,830	4,980	1,520	247			4		13		Checks	C. T.	Do.
43	15	16.5	30.2	10.5	45	0	3	6,800	6,240	1,695	283			4		8	4	do	C. S.	Do.
44	19	22.2	27.8	22.4	24	0	1	6,730	3,610	1,764	298	2		4		10			C. T.	Do.
45	8	23.5	27.6	18.9	21	0	1	6,720	4,040	1,530	266	1	1		1	3	1		C. S.	Do.
46	19	21.8	26.4	15.2	21	0	3	6,665	3,520	1,551	359					23		Checks	C. S.	Do.
47	7	25.6	25.6	27.9	30	0	1	6,650	4,700	1,482	287			4		17		do	C. S.	Do.
48	25	20.1	23.8	14.3	18	0	1	6,610	4,790	1,496	283					23		do	C. S.	Do.
49	7	23.6	25.3	31.1	24	0	1	6,550	4,790	1,380	283			2		21	3	do	C. S.	Do.
50	15	20.1	22.9	6.5	16	0	3	6,520	3,370	1,389	278	2		5		42	1	do	C. T.	Small knot on top face 8 inches from center.

[1] C. indicates compression failure, T. tension failure, and S. horizontal shear failure. Failures are indicated in the order of their occurrence.

TABLE 15.—*Data on individual bending tests of air-seasoned timbers of commercial sizes*—Continued.

Species.	Size.	Reference number.	Months seasoned.	Moisture.	Dry weight per cubic foot.	Rings per inch.	Summer wood.	Sap.	Cross-section classification.	Modulus of rupture per square inch.	Fiber stress at elastic limit per square inch.	Modulus of elasticity per square inch.	Horizontal shear.	Number of knots.						Other defects.	Manner of failure.	Cause of first failure.
														Vol. I.		Vol. II.		Vol. III.				
														Less than 1½ inches.	1½ inches and over.	Less than 1½ inches.	1½ inches and over.	Less than 1½ inches.	1½ inches and over.			
	Inches.			*P. ct.*	*Lbs.*		*P. ct.*	*P. ct.*		*Lbs.*	*Lbs.*	*1,000 lbs.*										
Douglas fir.....	8 x 16..	51	19	19.4	25.4	9.2	21	0	3	6,500	3,990	1,595	281	....	....	1	....	25	....	Checks.....	C. T. S..	No apparent cause.
		52	20	19.6	25.1	9.1	21	0	3	6,480	4,000	1,562	279	....	....	2	....	22	2	.....do.....	C. S.....	Do.
		53	7	29.2	28.2	20.6	30	0	1	6,460	4,700	1,490	348	....	....	....	....	9	....	.....do.....	C. S.....	Do.
		54	24	18.6	24.6	10.2	24	0	1	6,400	3,880	1,400	274	....	....	2	....	1	....	.....	C. T.....	Do.
		55	24	19.3	23.0	13.9	17	0	1	6,380	4,440	1,355	272	....	....	....	....	37	....	Checks.....	C. S.....	Do.
		56	14	25.2	26.6	13.4	26	0	1	6,320	4,170	1,500	253	....	....	2	....	23	....	.....	C. T.....	Do.
		57	5	25.3	28.9	14.2	21	0	1	6,230	4,830	1,485	273	....	....	....	....	4	3	Checks.....	C. S.....	Do.
		58	18	19.5	23.6	15.7	20	0	1	6,220	4,610	1,558	265	....	....	1	....	21	....	.....	C. S.....	Do.
		59	19	22.3	26.3	13.8	35	0	1	6,110	4,270	1,496	265	....	....	....	....	11	....	.....	S.....	Do.
		60	3	26.4	28.1	8.5	28	0	1	6,070	3,590	1,358	264	....	....	1	....	3	3	Checks.....	C. T.....	Do.
		61	6	21.8	28.0	4.0	33	0	1	6,050	5,140	1,455	241	1	1	....	....	19	....	.....do.....	C. S.....	Do.
		62	6	23.5	26.1	9.0	19	0	1	6,030	5,280	1,450	261	....	....	....	....	12	5	.....do.....	C. S.....	Do.
		63	25	15.3	26.6	8.8	19	0	3	6,030	4,230	1,695	259	2	....	2	....	30	....	.....do.....	C. S.....	Do.
		64	15	15.7	24.6	4.8	33	0	3	5,870	4,340	1,395	246	2	1	2	3	9	2	.....do.....	C. T. S..	Large knot on top face 8 inches from center.
		65	15	16.3	27.0	7.0	37	0	1	5,860	4,960	1,440	244	3	1	4	2	2	5	.....do.....	T. C.....	Irregular grain.
		66	14	21.6	27.9	14.1	22	0	1	5,840	4,050	1,689	229	....	....	2	....	21	....	.....do.....	C. S.....	No apparent cause.
		67	25	18.4	24.5	6.7	24	0	3	5,830	4,510	1,532	249	....	....	....	....	....	....	.....do.....	C. S.....	Do.
		68	24	11.7	25.3	6.8	18	0	3	5,760	4,110	1,365	246	4	....	5	....	42	1	.....do.....	C. T.....	Small knot on top face 30 inches from center.
		69	13	21.0	25.2	6.1	15	0	3	5,740	3,150	1,440	228	....	....	6	....	42	....	.....do.....	C. T.....	No apparent cause.
		70	6	22.3	30.1	6.7	30	0	1	5,720	4,730	1,370	231	....	1	....	....	6	3	.....do.....	S.....	Do.
		71	27	19.5	25.1	6.1	14	0	3	5,580	4,690	1,313	223	2	....	....	....	26	....	.....do.....	C. T.....	Do.
		72	15	16.6	27.6	14.0	41	0	1	5,560	4,960	1,380	231	....	1	2	....	7	....	Cross grain....	T.....	Irregular grain.
		73	33	18.3	31.8	11.6	26	0	4	5,130	4,170	1,670	220	....	....	3	2	13	7	Checks.....	S.....	Apparently influenced by pitch streak.
		74	27	18.0	27.8	20.4	23	0	1	5,130	4,070	1,591	201	2	....	....	....	3	1	Cross grain....	C. T.....	No apparent cause.
		75	5	20.8	28.6	5.4	27	0	3	5,080	4,910	1,320	214	2	2	....	1	29	7	Checks.....	T.....	Irregular grain caused by knots.
		76	15	16.3	27.6	7.7	34	0	3	5,040	4,450	1,665	208	4	5	2	....	13	2	.....do.....	T.....	2 large corner knots 14 inches from center.

		77	27	19.1	27.3	12.4	21	0	1	4,990	4,660	1,566	197	2				24		do	T	Cross grain and large loose corner knot at center.
		78	5	25.7	29.6	14.1	22	0	3	4,840	4,550	1,620	212					7	3	do	T	Cross grain.
		79	6	21.8	28.0	6.6	28	0	1	4,640	4,120	1,270	200	3	1	2	1	17	4	do	C. S.	No apparent cause.
		80	25	19.0	24.1	16.1	19	0	1	4,560	2,930	1,175	256	1				12			C. S.	Do.
		81	5	25.8	29.3	8.1	20	0	3	4,490	3,720	1,195	183	1	2	2	1	8	6	Checks	T	Large knot on lower face 19 inches from center.
		82	5	23.1	26.1	4.5	21	0	3	4,390	3,230	1,500	173	4		3		32	1	do	C. T. S.	No apparent cause.
		83	5	28.7	28.0	5.8	22	0	3	4,140	3,440	1,190	180	1	1	2		24	4	do	S. T.	Do.
		84	33	18.2	27.0	5.8	33	0	1	3,650	2,410	1,072	156		3	2	1	8	6	do	C. T.	Do.
		85	6	21.1	27.3	6.8	30	0	1	3,560	3,480	1,320	143	2				10	4	do	T	Cross grain and large corner knot 60 inches from center.
		86	6	28.4	25.1	3.4	21	0	3	3,480	3,070	1,090	146	5	1	4	1	34	4	do	C. T.	No apparent cause.
		87	5	23.7	28.6	5.0	25	0	4	3,060	3,060	1,260	129	2		5	2	24	3	do	T	Small corner knot 12 inches from center.
		88	6	27.8	26.1	2.7	36	0	3	2,970	2,860	872	117	7		7		32	3	do	T	Small knot near lower edge 6 inches from center.
		89	33	14.4	28.3	5.5	29	0	1	2,810	2,670	1,204	111	3	2	3	2	13	10	do	T	Large loose corner knot 25 inches from center.
		90	33	16.0	28.5	6.6	25	0	1	2,610	1,790	928	111			1	3	11	12	do	T	Irregular grain due to several large knots.
		91	33	15.8	28.1	6.4	26	0	1	2,380	1,870	927	100		3		3	16	7	do	T	Do.
Average					20.8	27.7	13.1	26	0		6,372	4,563	1,549	269								
Douglas fir	5 x 8	92	27	15.2	28.9	14.9	50	0	1	10,170	7,550	2,099	325			4		6		do	C. T.	Small knot on top face.
		93	25	14.6	30.5	6.0	44	0	3	10,110	8,170	2,481	325	2		3		12		do	T. C.	No apparent cause.
		94	27	15.6	35.3	16.7	65	0	1	10,110	6,800	2,160	326	1						do	T	Cross grain.
		95	27	14.3	26.6	19.9	35	0	1	9,350	6,290	1,997	298			2		1			C. T.	No apparent cause.
		96	27	13.9	27.6	14.0	30	10	2	8,480	5,040	2,026	276			3		5			C. T.	Small knot on top face 10 inches from center.
		97	25	14.8	28.5	21.1	48	0	1	8,210	5,520	1,658	265					2		Cross grain	T	Cross grain.
		98	25	14.8	28.5	21.1	51	0	1	7,910	5,300	1,431	256							do	T	Do.
		99	25	14.8	31.3	20.8	48	0	1	7,870	6,560	2,120	253							do	T	Do.
		100	27	14.3	25.9	10.8	38	0	2	7,770	5,840	1,949	245			11		8		Checks	C. T.	Small knot on top face 7 inches from center.
		101	27	14.3	28.3	9.6	52	0	4	7,740	5,020	2,001	248	5		2	1	13	5		T. C.	No apparent cause.
		102	25	14.8	27.8	14.3	41	1	1	7,720	4,360	1,750	249	3		4	1	6	4		T	Do.
		103	25	15.0	33.8	11.8	48	0	1	7,590	6,410	2,393	245	2				3			T	Large corner knot 11 inches from center.
		104	27	15.0	26.5	29.9	57	0	1	7,580	6,320	1,920	241					1		Checks	C. T.	No apparent cause.
		105	25	15.5	29.3	9.5	46	0	1	7,480	5,350	2,099	241					4		Cross grain	T	Cross grain.
		106	27	15.0	27.2	7.9	28	0	3	7,480	4,850	1,641	241	2		9		15	3		C. T.	Small knot on top face 5 inches from center.
		107	25	15.0	30.3	18.3	45	1	1	7,240	7,240	2,121	234	1	1	1	1	5	1		T	Large loose corner knot 16 inches from center.
		108	25	15.2	29.7	11.1	44	0	1	7,170	5,000	1,765	230	5	1	10	1	10	5		T. C.	Small corner knot 10 inches from center.
		109	27	15.6	25.6	4.8	29	0	4	6,670	4,620	1,739	215	1	1	11		20	2	Checks	C. T.	No apparent cause.
		110	25	15.8	28.6	6.4	34	0	2	6,220	4,590	1,584	202	2		9	2	3	2		T	Do.

TABLE 15.—*Data on individual bending tests of air-seasoned timbers of commercial sizes*—Continued.

Species.	Size.	Reference number.	Months seasoned.	Moisture.	Dry weight per cubic foot.	Rings per inch.	Summer wood.	Sap.	Cross-section classification.	Modulus of rupture per square inch.	Fiber stress at elastic limit per square inch.	Modulus of elasticity per square inch.	Horizontal shear.	Number of knots. Vol. I. Less than 1½ inches.	Vol. I. 1½ inches and over.	Vol. II. Less than 1½ inches.	Vol. II. 1½ inches and over.	Vol. III. Less than 1½ inches.	Vol. III. 1½ inches and over.	Other defects.	Manner of failure.	Cause of first failure.
	Inches.			*P. ct.*	*Lbs.*		*P. ct.*	*P. ct.*		*Lbs.*	*Lbs.*	*1,000 lbs.*										
Douglas fir	5 x 8	111	25	14.5	27.0	7.0	38	0	3	6,210	4,120	1,881	198	4	....	4	1	15	5	.....	T.....	Large corner knot 16 inches from center.
		112	25	15.0	32.5	16.5	53	0	1	6,040	4,440	1,895	196	....	....	....	....	1	2	Cross grain....	C. T....	Cross grain.
		113	25	14.8	24.5	6.4	35	0	3	5,510	4,380	1,668	177	3	1	9	....	15	3	.....	T. C....	No apparent cause.
		114	25	15.2	31.4	6.0	47	0	1	5,320	4,750	2,385	169	6	2	4	....	17	2	Checks.....	S. T....	Apparently influenced by checks.
		115	27	15.2	28.1	16.0	54	0	1	4,850	3,820	1,906	154	1	....	2	2	9	4	.....	T.....	No apparent cause.
		116	25	14.3	27.2	6.5	35	0	1	4,660	3,120	1,343	149	1	1	2	1	12	8	.....	T.....	Large corner knot 10 inches from center.
		117	25	15.3	27.9	6.8	32	0	1	4,040	4,040	1,622	129	4	1	5	2	11	8	.....	T.....	Cross grain.
		118	25	15.5	30.3	10.0	42	0	1	3,950	3,830	1,675	126	3	2	7	3	16	6	Cross grain....	T.....	Do.
		119	25	15.3	27.0	9.1	40	0	1	3,680	3,520	1,420	118	....	2	1	1	8	7	.....do.....	T.....	Large knot on bottom face 10 inches from center.
		120	25	14.7	25.2	4.4	23	1	4	3,440	2,920	1,290	111	2	3	12	1	26	8	.....	T.....	Irregular grain.
		121	25	15.1	25.9	7.8	34	0	4	2,730	2,170	1,583	88	6	3	6	1	13	5	.....	T.....	Do.
Average..	.....	.....	.....	14.9	28.6	12.2	41	0	.....	6,777	5,065	1,853	218									
Shortleaf pine..	8 x 16..	1	16	18.2	36.3	12.0	37	15	3	6,540	4,080	1,652	433	.....	.....	.....	.....	.....	.....	Checks.....	S.....	Apparently influenced by checks.
		2	16	16.0	28.2	9.0	25	17	3	6,350	3,950	1,486	418	.....	.....	.....	.....	3	2	.....do.....	T. S....	Cross grain.
		3	16	16.9	27.7	16.0	27	5	1	5,200	4,630	1,414	342	.....	.....	.....	.....	3	1	.....do.....	T.....	No apparent cause.
Average....	.....	.....	.....	17.0	30.7	12.3	30	12	.....	6,030	4,220	1,517	398									
Shortleaf pine..	8 x 14..	4	16	15.5	32.1	13.0	28	30	3	6,310	4,990	1,811	363	.....	.....	.....	1	3	3	.....do.....	S.....	Due to checks.
		5	16	16.4	33.2	12.0	33	45	3	4,910	4,110	1,788	279	.....	.....	.....	.....	.....	.....	.....do.....	S. C. T..	Do.
		6	16	16.0	31.0	12.0	26	5	3	4,820	3,660	1,671	278	.....	.....	.....	2	6	4	.....do.....	T.....	Large corner knot 63 inches from center.
Average..	.....	.....	.....	16.0	32.1	12.3	29	27	.....	5,347	4,253	1,757	307									

Shortleaf pine..	8 x 12..	7	16	15.5	29.4	15.0	36	10	1	8,760	6,380	1,649	429	....	....	1	2	3	5	.....do.....	T.....	No apparent cause—brash failure.
		8	16	16.2	35.9	14.0	38	25	3	8,650	6,240	2,181	428	....	....	....	....	....	....	.....do.....	S.....	Due to checks.
		9	16	15.9	30.8	13.0	38	15	3	7,940	5,930	1,599	388	....	....	....	....	9	....	.....	T.....	No apparent cause—brash failure.
		10	16	17.3	32.2	9.0	29	60	3	7,430	5,460	2,146	367	....	....	....	....	....	....	Checks.....	S.....	Due to checks.
		11	16	15.9	30.4	14.0	33	10	3	6,410	5,530	1,725	314	....	....	1	1	7	4	Cross grain....	T.....	Due to checks.
		12	16	.....	.....	9.0	29	60	3	6,340	1,680	1,745	313	....	....	....	....	....	....	Checks.....	S. C. T..	Large corner knot 32 inches from center.
		13	16	14.9	29.2	13.0	27	15	3	5,790	4,140	1,576	287	1	1	....	1	4	3	.....do.....	T.....	
Average..	.....	.....	.....	16.0	31.3	12.4	33	28	.....	7,331	5,051	1,803	361									
Shortleaf pine..	5 x 8...	14	16	11.6	34.9	7.0	27	30	3	10,870	6,830	2,139	351	....	....	....	....	10	....	.....do.....	S.....	Apparently influenced by checks.
		15	16	12.4	36.9	9.0	31	35	3	10,600	8,290	2,340	337	....	....	2	....	20	....	.....	C. T....	No apparent cause.
		16	16	12.4	32.9	14.0	31	25	3	9,390	7,980	1,957	301	....	....	....	....	4	1	.....	T.....	Cross grain.
		17	16	12.4	29.6	10.0	28	60	1	8,890	7,460	1,746	287	....	....	1	....	12	4	.....	T.....	No apparent cause.
		18	16	12.0	32.2	8.0	25	35	1	8,670	5,670	1,738	277	....	1	4	2	15	8	.....	T.....	Irregular grain.
		19	16	12.4	31.6	15.0	31	35	1	7,820	6,510	1,989	251	....	....	1	1	5	3	.....	T.....	Cross grain.
Average..	.....	.....	.....	12.2	33.0	22.5	29	37	.....	9,373	7,123	1,985	301									
Western larch..	8 x 16..	1	46	21.7	33.6	16.4	.....	0	3	7,010	4,340	1,559	449	....	....	5	....	12	....	Checks.....	S. T. C..	Apparently influenced by checks.
		2	45	.....	.....	23.2	.....	0	1	6,935	4,580	1,659	444	1	....	....	....	5	....	.....do.....	S. C. T..	Do.
		3	45	17.0	26.8	20.8	.....	0	3	6,915	4,155	1,411	443	....	....	....	....	41	....	.....do.....	C. T....	No apparent cause.
		4	46	17.4	32.9	22.4	.....	5	3	6,470	3,650	1,410	415	....	....	2	3	28	2	.....do.....	T. C. S..	Irregular grain due to knots.
		5	46	18.7	25.8	17.4	.....	0	3	6,290	2,830	1,378	403	....	....	1	1	22	7	.....do.....	S.....	Apparently influenced by checks.
		6	46	17.7	26.9	21.0	.....	0	3	5,900	4,830	1,595	378	....	....	....	....	24	....	.....do.....	S.....	Do.
		7	45	16.7	29.5	23.6	.....	2	3	5,900	3,975	1,268	377	1	....	8	2	10	4	.....do.....	T. C. S..	No apparent cause—brash failure.
		8	46	19.0	29.4	15.4	.....	0	3	5,890	3,330	1,427	376	1	....	6	1	17	1	.....do.....	S.....	Apparently influenced by checks.
		9	46	19.4	26.8	25.9	.....	2	1	5,730	3,580	1,275	367	....	....	1	1	27	....	.....do.....	C. S....	No apparent cause.
		10	46	20.0	27.8	16.5	.....	0	3	5,670	3,105	1,544	364	....	....	3	....	34	....	.....do.....	S. C....	Apparently influenced by checks.
		11	46	17.4	30.6	21.5	.....	0	3	5,640	4,105	1,490	360	....	....	1	....	22	4	.....do.....	T. C. S..	Irregular grain due to knots.
		12	46	18.4	25.8	23.4	.....	1	3	5,590	3,050	1,204	360	9	....	4	....	34	6	.....do.....	T. C....	Small corner knot 8 inches from center.
		13	46	19.4	26.8	25.1	.....	2	3	5,415	4,025	1,335	347	....	....	....	....	19	....	.....do.....	T. C....	No apparent cause.
		14	46	18.0	30.5	23.2	.....	0	3	5,415	3,515	1,510	348	....	....	....	....	25	....	.....do.....	S. C. T..	Apparently influenced by checks.
		15	46	.....	.....	20.4	.....	0	3	5,310	3,135	1,848	341	....	....	5	....	28	....	.....do.....	S.....	Do.
		16	46	20.5	38.7	22.2	.....	0	1	5,225	3,880	1,710	337	....	....	....	....	6	....	.....do.....	T. S....	Cross grain.
		17	46	19.0	27.0	29.1	.....	2	3	5,130	3,230	1,448	329	....	....	2	2	8	....	.....do.....	S. C....	Apparently influenced by checks.
		18	46	17.7	27.8	26.6	.....	0	3	4,960	2,990	1,275	315	5	1	4	2	23	6	.....do.....	T.....	Large corner knot 45 inches from center.

TABLE 15.—*Data on individual bending tests of air-seasoned timbers of commercial sizes*—Continued.

Species.	Size.	Reference number.	Months seasoned.	Moisture.	Dry weight per cubic foot.	Rings per inch.	Summer wood.	Sap.	Cross-section classification.	Modulus of rupture per square inch.	Fiber stress at elastic limit per square inch.	Modulus of elasticity per square inch.	Horizontal shear.	Number of knots.						Other defects.	Manner of failure.	Cause of first failure.
														Vol. I.		Vol. II.		Vol. III.				
														Less than 1½ inches.	1½ inches and over.	Less than 1½ inches.	1½ inches and over.	Less than 1½ inches.	1½ inches and over.			
	Inches.			*P. ct.*	*Lbs.*		*P. ct.*	*P. ct.*		*Lbs.*	*Lbs.*	*1,000 lbs.*										
Western larch..	8 x 16..	19	46	18.7	29.4	12.4	.....	0	3	4,960	2,550	1,341	319	7	1	6	2	36	5	.....do.....	T.....	Large knot on bottom face 29 inches from center.
		20	46	16.1	26.6	20.4	.....	0	3	4,570	1,930	1,235	293	6	....	6	2	37	1	.....do.....	T.....	Irregular grain.
		21	46	17.3	28.4	23.6	.....	0	3	4,520	2,600	1,196	288	1	....	7	3	23	6	.....do.....	T.....	No apparent cause—brash failure.
		22	46	16.5	25.3	30.9	.....	0	3	3,065	2,030	1,179	197	8	1	....	1	19	4	.....do.....	S. C. T..	Apparently influenced by checks.
		23	45	17.6	28.8	21.9	.....	0	1	2,615	1,470	1,103	167	1	....	3	....	23	5	.....do.....	T.....	Cross grain.
Average..	.....	.....	.....	18.3	28.8	21.9	.....	1	.....	5,440	3,343	1,409	349									
Western larch..	8 x 12..	24	45	19.6	38.4	26.2	.....	0	3	9,345	5,525	2,095	445	.....	.....	.....	.....	.....	.....	.....do.....	S.....	Apparently influenced by checks.
		25	45	17.9	30.4	26.9	.....	0	3	8,800	5,650	1,900	417	.....	.....	1	....	13	....	.....do.....	C. T. S..	No apparent cause.
		26	45	17.2	33.1	26.1	.....	0	3	8,640	4,770	1,661	412	2	....	1	....	21	....	.....do.....	T. S.....	Do.
		27	45	18.1	30.7	23.3	.....	1	3	7,980	4,745	1,795	381	2	.....	....	....	12	....	.....do.....	C. T. S..	Do.
		28	45	18.5	32.6	26.5	.....	0	3	7,885	4,210	1,832	377	.....	.....	3	2	8	1	.....do.....	C. T....	Large knot on top face 13 inches from center.
		29	46	16.7	30.0	25.6	.....	0	1	7,520	4,480	1,423	358	3	....	.....	.....	10	....	.....do.....	C. T....	No apparent cause.
		30	47	17.8	28.5	27.2	.....	0	1	7,440	4,170	1,591	355	....	2	.....	.....	7	....	.....do.....	C. S.....	Large knot on corner 26 inches from center.
		31	45	18.0	30.3	27.4	.....	0	1	7,420	4,905	1,580	352	.....	.....	3	....	14	....	.....do.....	T. S.....	Cross grain.
		32	47	16.3	26.2	24.3	.....	1	1	7,180	4,050	1,454	340	.....	.....	2	....	10	....	.....	C. T.....	No apparent cause.
		33	47	17.3	26.9	20.6	.....	0	3	6,880	4,750	1,519	327	.....	.....	13	....	19	....	Checks.....	C. T....	Small knot on top face 33 inches from center.
		34	47	18.6	31.1	21.6	.....	0	3	6,810	4,420	1,718	324	.....	.....	1	....	9	....	.....do.....	T.....	No apparent cause—brash failure.
		35	45	18.0	33.0	24.0	.....	0	3	6,690	3,645	1,720	321	7	....	6	....	24	3	.....do.....	T.....	Do.
		36	47	19.1	30.6	20.9	.....	0	3	6,650	3,820	1,730	319	2	....	7	....	10	....	.....do.....	S. C.....	Apparently influenced by checks.

		37	45	18.2	28.6	30.1		0	3	6,500	2,920	1,754	311	6		5	5	36	1	do	T. C.	Small corner knot 20 inches from center.
		38	47	16.6	27.2	20.8		0	3	6,110	3,700	1,445	292	1	1	1		13		do	C. S.	No apparent cause.
		39	45	18.0	27.4	23.8		0	3	6,085	3,440	1,209	291	7		12	2	28	3	do	T.	Irregular grain due to knots.
		40	45	18.5	29.5	30.5		0	3	5,900	2,995	1,579	282	4				17	3	do	T.	Small corner knot 19 inches from center.
		41	47	17.7	27.9	28.5		0	1	5,625	2,815	1,548	267	8	1	4	2	31	4		T.	Irregular grain due to knots.
		42	47	17.5	27.6	24.6		0	3	5,310	2,450	1,653	251	8		6		29	4	Checks	T. C.	Knot cluster on bottom face 13 inches from center.
		43	47	17.9	29.7	10.3		0	3	5,150	3,010	1,352	244	1	8	14	4	32	15	do	T.	Large corner knot 32 inches from center.
		44	47	17.3	28.1	13.3		0	3	5,120	2,830	1,303	242	7	2	11	2	24	12	do	T.	Small knot on bottom face 2 inches from center.
		45	46	16.8	26.5	27.9		0	3	4,925	3,740	1,210	234			2		24		do	T.	Cross grain.
		46	45	17.3	33.3	21.5		1	3	4,910	2,690	1,630	233			1	1	25	2	do	T.	Do.
		47	47	17.0	25.2	11.5		0	3	4,905	3,330	1,249	234	2	1	1	6	26	7	do	T. C.	Large knot on bottom face 33 inches from center.
		48	45	19.9	30.9	24.6		2	3	4,805	2,880	1,464	230			2		20	3	Checks	T.	No apparent cause—brash failure.
		49	45	17.9	30.9	21.6		1	4	4,620	3,235	1,439	221			8		18		do	S. T.	Apparently influenced by checks.
		50	47	17.9	28.6	21.9		0	1	4,490	2,077	1,240	212	3	3	8	1	28	4	do	T.	Small corner knot at center.
		51	45	20.0	30.4	24.6		0	3	3,125	1,720	1,659	150			1		8		do	S. T.	Apparently influenced by checks.
		52	47	15.7	26.0	22.8		0	3	2,560	2,320	1,174	122	7		15	1	23	1	do	T.	Irregular grain caused by small knot 4 inches from center.
Average				17.8	29.6	23.4				6,186	3,631	1,549	295									
Western larch	5 x 8	53	42	14.6	40.3	23.7		0	1	11,760	7,020	2,368	356							do	T.	No apparent cause.
		54	42	13.9	32.9	23.0		0	1	9,750	6,780	2,077	299							do	T.	Cross grain.
		55	42	13.2	31.1	32.0		0	1	7,740	5,400	1,706	234			7		19		do	T. C.	No apparent cause.
		56	42	13.1	27.7	28.4		0	2	7,470	4,470	1,645	227			4		7		do	C. T.	Do.
		57	42	13.3	31.7	28.0		0	1	6,910	4,790	1,712	210	2		6		23	2	do	T. C.	Small corner knot 22 inches from center.
		58	42	12.9	25.5	30.7		1	1	6,730	4,650	1,314	205			4		9		do	C. T.	No apparent cause—brash failure.
		59	42	13.6	27.0	23.6		0	1	6,530	4,500	1,392	200			13		16			T. C.	Do.
		60	42	13.9	30.1	31.1		0	1	6,280	3,620	1,258	192	2		2	1	16		Checks	T.	Cross grain.
		61	42	13.6	26.0	29.2		0	1	4,930	3,420	1,234	150	6		3	1	18	2		T.	Irregular grain due to knots.
		62	42	13.8	34.3	26.6		0	1	4,480	2,650	1,491	134	3		6	1	26			T.	Cross grain.
Average				13.6	30.7	27.6		0		7,258	4,730	1,620	221									

TABLE 15.—*Data on individual bending tests of air-seasoned timbers of commercial sizes*—Continued.

Species.	Size.	Reference number.	Months seasoned.	Moisture.	Dry weight per cubic foot.	Rings per inch.	Summer wood.	Sap.	Cross-section classification.	Modulus of rupture per square inch.	Fiber stress at elastic limit per square inch.	Modulus of elasticity per square inch.	Horizontal shear.	Number of knots.						Other defects.	Manner of failure.	Cause of first failure.
														Vol. I.		Vol. II.		Vol. III.				
														Less than 1½ inches.	1½ inches and over.	Less than 1½ inches.	1½ inches and over.	Less than 1½ inches.	1½ inches and over.			
	Inches.			*P. ct.*	*Lbs.*		*P. ct.*	*P. ct.*		*Lbs.*	*Lbs.*	*1,000 lbs.*										
Loblolly pine..	8 x 16..	1	22	19.7	40.4	8.0	54	2	3	8,560	4,990	909	620	....	....	....	....	....	....	Checks.....	T. S.....	No apparent cause.
		2	22	21.2	39.8	7.5	61	5	1	7,820	4,930	1,777	575	....	....	....	1	....	....	.....do.....	T. S.....	Cross grain.
		3	19	21.7	36.8	7.0	43	73	3	7,500	4,200	1,670	549	....	....	....	....	....	....	.....do	T. S.....	No apparent cause.
		4	22	19.2	35.5	7.5	59	2	3	7,340	4,180	1,677	536	....	....	....	....	....	....	.....do.....	S.....	Apparently influenced by checks.
		5	24	25.5	33.7	6.0	.....	40	3	7,200	3,640	1,715	296	....	....	....	....	....	....	.....	T.....	No apparent cause.
		6	20	19.5	31.4	9.5	38	5	3	7,070	4,310	2,002	523	....	....	....	....	1	2	Checks.....	S.....	Apparently influenced by checks.
		7	22	18.8	34.5	9.0	51	11	1	6,430	4,830	1,488	471	....	....	....	....	2	2	.....do.....	T.....	Cross grain.
		8	24	26.1	29.3	5.0	.....	35	3	6,420	3,250	1,760	264	....	....	....	....	2	2	.....	T.....	No apparent cause.
		9	21	20.3	36.4	5.5	45	61	3	6,380	3,740	1,695	470	....	....	....	....	3	2	Checks.....	T.....	Do.
		10	20	19.1	36.8	9.5	54	0	3	6,360	4,110	1,780	468	....	....	....	....	....	....	.....do.....	S.....	Apparently influenced by checks.
		11	20	19.0	28.6	6.5	29	65	3	6,120	3,110	1,398	452	....	....	....	....	1	....	.....do.....	S.....	Do.
		12	20	19.3	31.2	7.2	44	34	3	6,040	4,840	1,714	438	....	....	....	....	1	1	.....do.....	T. S.....	No apparent cause.
		13	22	18.2	30.8	5.9	30	0	3	5,870	4,400	1,458	432	....	....	....	....	1	2	.....do.....	S. T.....	Apparently influenced by checks.
		14	22	20.0	33.7	9.5	46	8	3	5,160	.....	.....	380	....	....	....	....	1	2	Cross grain....	T.....	Cross grain.
Average..	.....	.....	.....	20.5	34.2	7.4	46	24	.....	6,734	4,195	1,619	462									
Loblolly pine..	6 x 16..	15	24	18.5	34.3	5.6	.....	25	3	6,100	3,785	1,444	372	....	....	....	....	....	....	Checks.....	S. T.....	No apparent cause.
		16	24	21.6	28.1	6.4	.....	85	1	4,180	1,986	1,303	256	....	....	....	....	....	....	.....	C. T.....	Do.
		17	24	20.1	32.4	5.0	.....	40	3	3,990	1,915	1,643	256	....	....	....	....	1	....	Checks.....	S. T.....	Apparently influenced by checks.
		18	24	20.6	25.6	3.0	.....	40	3	2,910	2,040	906	178	....	....	1	1	2	6	.....	T.....	Cross grain.
Average..	.....	.....	.....	20.2	30.1	5.0	.....	48	.....	4,295	2,432	1,324	266									
Loblolly pine...	6 x 10..	19	15	24.4	32.4	4.0	.....	30	3	7,180	3,630	1,605	207	....	....	1	....	5	1	Checks.....	C. T.....	No apparent cause.
		20	15	19.9	29.3	6.0	.....	20	3	5,890	2,830	1,334	162	....	1	2	2	4	8	.....	T.....	Irregular grain.
		21	15	19.7	29.3	4.0	.....	25	3	5,430	2,840	1,410	150	1	4	....	4	4	12	.....	T.....	Do.

Average				21.3	30.3	4.7		25		6,167	3,100	1,449	173							
Loblolly pine	4 x 12	22	15	17.1	28.7	4.9		26	1	7,130	2,950	1,208	222	1		1		3	2		C. T.	Large knot near center of top edge.
		23	15	20.2	30.6	5.5		25	1	7,000	4,180	1,460	227		1	1	1	4	6		T.	Irregular grain.
		24	15	19.5	30.6	4.3		8	3	6,860	2,860	1,469	220	1	1			5	4		T.	No apparent cause.
		25	15	22.3	27.4	4.1		70	1	1,990	862	860	71	3	1	1	1	2	4		T.	Large knot at center of lower corner.
Average				19.8	29.3	4.7		32		5,745	2,713	1,249	185									
Loblolly pine	8 x 8	26	24	19.9	33.1	10.0		38	4	7,690	4,740	1,561	148	3	1	2		12			T.	No apparent cause.
		27	24	17.8	31.8	9.0		1	3	7,280	5,090	1,728	152	2	6	1	2	1	3		T.	Unsound knot on bottom face.
		28	24	25.5	31.8	5.0		40	4	5,750	3,050	1,640	119	1	7	1	4	2	6		T.	Irregular grain due to large knot 18 inches from center.
		29	24	18.6	26.8	4.0		16	3	4,700	3,835	1,164	98		3		4	1	12	Checks	T.	Large knot on lower edge 20 inches from center.
		30	24	19.2	36.2	4.0		70	3	3,970	2,770	987	80	3	2	2	2	11	16		T.	No apparent cause.
		31	12	25.7	24.3	2.7		75	3	3,620	2,020	1,060	75		3			12	17		T. C.	Irregular grain due to knot 15 inches from center.
		32	24	24.4	26.8	3.6		18	3	2,940	1,348	606	61	4	2	2	5	11	15	Checks	T.	Corner knot 12 inches from center.
		33	12	27.7	23.1	3.1		75	3	2,880	1,995	812	60	3	2	2	4	5	15		C. T.	No apparent cause.
		34		26.9	23.1	3.0		83	3	2,180	1,280	664	45	2	2	3	3	1	1		T.	Irregular grain caused by knot 13 inches from center.
Average				22.9	28.6	4.9		46		4,557	2,903	1,136	93									
Loblolly pine	6 x 7	35	16	19.0	30.6	7.2		50	3	5,825	3,280	1,430	146	1	1	1	1	3	9		T.	Irregular grain caused by knot 3 inches from center.
		36	16	23.3	28.1	2.9		50	3	4,110	2,700	1,142	87	3	5		4	9	11		T.	Irregular grain caused by knot 23 inches from center.
Average				21.1	29.4	5.0		50		4,968	2,990	1,286	116									
Loblolly pine	4 x 8	37	16	19.0	33.1	6.0		5	3	8,370	3,160	1,175	275	4	1	3		17	2		T.	Irregular grain caused by knot 11 inches from center.
		38	16	19.0	31.8	10.0		17	3	8,030	4,900	1,695	264	3		1	1	18	1		T.	No apparent cause.
		39	16	19.9	26.8	10.0		55	1	7,270	4,360	1,405	195	1	1	1	2	3	2		T.	Do.
		40	17	21.6	29.4	10.0		22	3	6,240	3,520	1,140	172	1	3	4	3	9	9		T.	Do.
		41	16	20.8	31.2	9.7		15	1	6,160	2,810	1,232	220	1		2		18	4		T.	Irregular grain.
		42	16	14.5	31.2	12.2		14	3	5,980	3,155	1,145	196		1	3	1	13	4		T.	Large corner knot 14 inches from center.

TABLE 15.—*Data on individual bending tests of air-seasoned timbers of commercial sizes*—Continued.

Species.	Size.	Reference number.	Months seasoned.	Moisture.	Dry weight per cubic foot.	Rings per inch.	Summer wood.	Sap.	Cross-section classification.	Modulus of rupture per square inch.	Fiber stress at elastic limit per square inch.	Modulus of elasticity per square inch.	Horizontal shear.	Number of knots. Vol. I. Less than 1½ inches.	Vol. I. 1½ inches and over.	Vol. II. Less than 1½ inches.	Vol. II. 1½ inches and over.	Vol. III. Less than 1½ inches.	Vol. III. 1½ inches and over.	Other defects.	Manner of failure.	Cause of first failure.
	Inches.			*P. ct.*	*Lbs.*		*P. ct.*	*P. ct.*		*Lbs.*	*Lbs.*	*1,000 lbs.*										
Loblolly pine..	4 x 8..	43	16	20.6	26.8	6.0	.....	75	3	3,860	2,400	1,022	129	2	2	....	2	12	11	.....	T.....	Irregular grain.
		44	16	20.3	23.7	8.7	.....	55	3	3,640	2,770	790	120	1	2	1	1	13	9	.....	T.....	Do.
Average..	.....	.....	.....	19.5	29.2	9.1	.....	32	.....	6,194	3,384	1,200	196									
Tamarack.....	6 x 12..	1	8	16.4	29.7	13.1	.....	5	1	7,470	4,230	1,375	424	5	....	....	....	29	....	Checks.....	C. T.....	No apparent cause.
		2	8	26.5	30.9	21.3	.....	5	3	5,650	4,040	1,310	315	....	....	....	....	11	....	.....do.....	S.....	Due to checks and shake.
		3	8	23.0	31.8	15.5	.....	2	3	5,200	3,420	1,463	294	2	....	3	....	16	....	.....do.....	S.....	Do.
		4	8	27.5	30.6	16.3	.....	0	3	5,140	2,880	1,390	290	....	....	....	....	16	2	.....do.....	S.....	Do.
		5	8	21.8	30.9	9.2	.....	2	3	4,740	2,600	1,110	266	4	....	6	....	26	1	.....do.....	T. C. T..	Irregular grain.
Average..	.....	.....	.....	23.0	30.8	15.1	.....	5	.....	5,640	3,434	1,330	318									
Tamarack.....	4 x 10..	6	8	14.6	31.0	9.4	.....	0	3	6,700	4,410	1,505	309	5	....	7	....	43	8	.....do.....	C. T.....	Small corner knot 5 inches from center.
		7	8	14.5	31.4	9.6	.....	0	3	5,420	4,250	1,305	253	8	2	3	1	37	9	.....do.....	T.....	Irregular grain.
		8	8	14.0	28.1	8.1	.....	0	3	4,850	3,550	1,270	263	2	1	6	....	46	7	.....do.....	T.....	No apparent cause—brash failure.
		9	8	14.5	30.8	11.6	.....	0	3	4,310	4,190	1,345	184	2	....	4	2	21	12	.....do.....	T.....	Do.
Average..	.....	.....	.....	14.4	30.3	9.7	.....	0	.....	5,320	4,100	1,356	252									
Western hemlock.	8 x 16..	1	29	18.5	31.1	16.0	54	0	1	8,520	5,080	1,945	540	....	....	....	....	1	....	.....do	C. S.....	No apparent cause.
		2	29	18.5	31.8	11.0	56	0	1	8,340	5,880	1,968	530	....	....	1	....	3	....	.....do.....	C. S.....	Do.
		3	29	18.6	31.7	17.0	47	0	3	8,190	4,260	2,101	522	....	....	3	....	7	2	.....do.....	C. S.....	Do.
		4	29	18.1	31.1	25.0	45	0	1	8,170	5,590	1,828	517	....	....	....	2	4	....	.....do.....	C. T. S..	Do.
		5	29	17.3	30.9	19.0	37	0	1	8,120	5,560	2,179	508	....	....	3	2	13	2	.....do.....	C. S.....	Do.
		6	29	17.4	28.3	12.0	47	0	1	7,990	4,870	1,799	504	....	....	1	1	3	1	.....do.....	C. T. S..	Do.
		7	29	18.5	30.8	21.0	41	0	1	7,960	5,620	1,878	502	....	....	....	....	8	....	.....do.....	C. T. S..	Do.
		8	38	17.2	29.5	15.7	46	0	3	7,830	4,590	1,999	496	....	....	....	1	....	3	.....do.....	C. S.....	Large knot on top face.
		9	29	17.2	28.5	14.0	48	0	1	7,440	3,860	1,731	472	1	1	....	....	14	2	.....do.....	C. T.....	No apparent cause.

	10	38	17.3	28.2	20.6	.....	0	1	7,300	4,630	1,803	463	....	....	1	1	2	1	.....	T.C.S..	Do.
	11	29	17.5	24.8	9.0	43	0	3	7,230	4,720	1,696	459	....	....	.....	.....	8	....	Checks.....	C. S.....	Do.
	12	29	18.0	32.1	29.0	51	0	1	7,220	5,590	2,401	451	....	....	.....	.....	26	.....	.....do.....	C. S.....	Do.
	13	29	17.9	28.8	27.0	46	0	1	7,220	4,620	1,825	452	....	....	1	....	12	1	.....do.....	C. S.....	Do.
	14	39	17.0	29.0	21.7	.....	0	1	7,170	4,950	2,007	453	....	....	.....	.....	.....	.....	.....do.....	C. S.....	Do.
	15	38	17.3	29.3	11.4	.....	0	1	7,150	4,900	1,845	454	....	....	1	....	.....	.....	.....do.....	C. S.....	Do.
	16	29	18.0	26.0	14.0	46	0	1	7,080	4,270	1,505	447	....	....	.....	.....	.....	.....	.....do.....	C. T.....	Do.
	17	29	18.2	28.1	25.0	38	0	1	7,040	6,230	1,841	442	....	....	4	....	9	2	.....do.....	C. S.....	Do.
	18	39	16.3	27.3	11.9	.....	0	3	6,930	4,280	1,767	440	1	1	2	....	7	1	.....do.....	C. T. S..	Do.
	19	38	16.4	27.9	17.2	.....	0	1	6,910	4,990	1,642	439	....	....	2	1	1	....	.....	C. T.....	Large knot on top face 40 inches from center.
	20	29	18.0	27.5	19.0	45	0	1	6,850	4,530	1,701	432	1	....	8	....	24	....	.....	C. S.....	No apparent cause.
	21	29	18.0	28.0	20.0	40	0	1	6,670	5,470	1,814	418	....	....	5	1	11	1	Checks.....	C. S.....	Do.
	22	39	16.4	25.2	22.4	.....	0	3	6,660	4,300	1,625	423	2	....	1	....	18	3	.....do.....	C. T. S..	Do.
	23	29	17.7	28.5	9.0	46	0	1	6,640	3,830	1,723	420	1	....	2	....	15	1	.....do.....	C. T. S..	Do.
	24	29	18.4	27.5	22.0	43	0	1	6,490	5,070	1,494	410	1	....	.....	.....	3	....	.....	C. S.....	Do.
	25	29	18.8	28.0	12.0	44	0	3	6,430	4,630	1,772	408	2	....	4	1	15	1	.....	C. S.....	Do.
	26	29	18.0	24.9	12.0	39	0	1	6,430	4,040	1,461	405	....	....	3	1	5	....	Checks.....	C. T. S..	Do.
	27	38	17.0	28.9	22.4	.....	0	1	6,340	4,660	2,057	400	....	....	.....	.....	5	....	.....do.....	T. S.....	Irregular grain on lower corner 60 inches from center.
	28	29	18.2	26.3	25.0	44	0	1	6,060	4,350	1,643	381	1	....	6	3	20	....	.....do.....	C. S.....	No apparent cause.
	29	38	17.4	24.9	12.3	.....	0	1	6,040	4,280	1,548	380	....	....	.....	.....	.....	.....	.....do.....	S.....	Apparently influenced by checks.
	30	39	16.3	26.9	10.0	.....	0	3	6,020	.....	.....	385	....	....	.....	.....	4	....	.....do.....	S. C.....	Do.
	31	29	18.6	28.5	20.0	40	0	1	5,940	5,190	1,556	376	....	....	2	....	9	2	.....do.....	S.....	Do.
	32	29	18.1	27.6	11.0	40	0	3	5,780	3,850	1,542	367	4	....	5	....	20	1	.....do.....	C. T. S..	No apparent cause.
	33	38	17.4	24.8	14.5	.....	0	1	5,680	3,780	1,390	357	....	....	.....	3	....	2	.....do.....	C. S.....	Large knot on top face 30 inches from center.
	34	39	16.2	25.3	22.7	.....	0	3	5,350	3,330	1,527	337	....	1	1	....	5	.....	.....do.....	T. C. S..	Ax mark on lower corner 18 inches from center.
	35	29	18.3	28.7	19.0	37	0	1	5,150	4,070	1,821	324	1	....	3	....	6	.....	.....do.....	S.....	Apparently influenced by checks.
	36	29	18.3	27.2	29.0	43	0	1	5,140	4,230	1,710	326	3	....	6	1	15	.....	.....do.....	C. S.....	No apparent cause.
	37	38	17.4	25.0	24.1	.....	0	1	4,940	3,460	1,684	312	....	....	.....	.....	3	.....	.....do.....	S. C.....	Apparently influenced by checks.
	38	39	16.2	26.1	14.6	.....	0	1	4,870	4,390	1,374	309	3	1	1	3	13	2	.....	T. C. T..	Irregular grain on lower corner 39 inches from center.
	39	29	17.9	28.3	11.0	46	0	1	4,860	3,050	1,595	307	3	....	2	....	8	1	Checks.....	T. S.....	Small rotten knot on lower corner 23 inches from center.
	40	29	18.5	26.0	23.0	44	0	3	4,730	3,710	1,642	301	3	....	.....	.....	14	.....	.....do.....	S.....	Apparently influenced by checks.
	41	39	16.7	26.3	12.6	.....	0	3	4,190	2,140	1,589	265	1	....	.....	.....	4	2	.....do.....	S. C. T..	Do.
	42	29	17.7	26.4	23.0	28	0	3	3,970	3,040	1,364	254	1	....	8	1	20	5	.....do.....	S.....	Do.
	43	29	17.2	26.4	10.0	48	0	1	3,860	2,570	1,497	244	....	....	4	2	3	7	.....do.....	S. T.....	Do.
	44	29	19.5	27.1	22.0	36	0	3	3,590	2,650	1,788	228	4	....	.....	.....	18	.....	.....do.....	S.....	Do.
Average..	.....	.....	17.7	27.9	17.8	43	0	.....	6,420	4,398	1,737	406									

TABLE 15.—*Data on individual bending tests of air-seasoned timbers of commercial sizes*—Continued.

Species.	Size.	Reference number.	Months seasoned.	Moisture.	Dry weight per cubic foot.	Rings per inch.	Summer wood.	Sap.	Cross-section classification.	Modulus of rupture per square inch.	Fiber stress at elastic limit per square inch.	Modulus of elasticity per square inch.	Horizontal shear.	Number of knots.						Other defects.	Manner of failure.	Cause of first failure.
														Vol. I.		Vol. II.		Vol. III.				
														Less than 1½ inches.	1½ inches and over.	Less than 1½ inches.	1½ inches and over.	Less than 1½ inches.	1½ inches and over.			
	Inches.			*P. ct.*	*Lbs.*		*P. ct.*	*P. ct.*		*Lbs.*	*Lbs.*	*1,000 lbs.*										
Redwood	8 x 16	1	24	56.3	23.3	20.8	.....	0	1	6,320	.....	.....	423	.....	.....	.....	.....	.....	.....	.....	C. T.	No apparent cause.
		2	24	29.0	24.3	18.9	.....	0	1	5,720	4,540	1,154	380	.....	.....	.....	.....	.....	.....	.....	T. C.	Do.
		3	42	16.8	23.2	17.1	.....	0	3	4,930	3,240	1,347	321	1	.....	3	1	11	5	.....	T.	Do.
		4	24	17.4	18.9	20.2	.....	0	1	4,580	3,610	820	310	.....	.....	4	.....	12	4	.....	C. T. S.	Do.
		5	42	16.7	17.4	21.2	.....	0	1	2,870	.....	.....	191	.....	.....	.....	2	2	5	.....	T. S.	Do.
		6	42	21.6	22.6	36.5	.....	0	3	2,150	.....	.....	142	3	1	3	4	6	4	.....	T.	Irregular grain caused by knot 56 inches from center.
Average				26.3	21.6	22.4	.....	0	.....	4,428	3,797	1,107	294									
Redwood	6 x 12	7	24	19.3	22.7	20.5	.....	0	1	4,990	4,210	977	255	.....	.....	.....	.....	.....	.....	.....	T.	No apparent cause.
		8	42	15.2	25.0	23.6	.....	0	1	3,820	3,180	527	191	.....	.....	.....	.....	.....	.....	.....	T.	Do.
		9	42	14.6	15.8	15.6	.....	0	1	3,040	2,890	732	151	.....	.....	.....	.....	.....	2	.....	T.	Do.
		10	24	15.7	21.1	14.2	.....	0	1	2,980	.....	.....	147	.....	.....	.....	.....	3	3	.....	T.	Do.
		11	42	16.0	24.2	23.8	.....	1	3	2,700	2,420	674	134	.....	.....	17	1	5	3	.....	T.	Do.
		12	24	15.8	19.5	8.4	.....	0	1	2,590	.....	.....	125	2	2	1	2	5	.....	.....	T.	Small knot on lower face 31 inches from center.
Average				16.1	21.4	17.7	.....	0	.....	3,353	3,175	728	167									
Redwood	7 x 9	13	42	15.5	22.9	16.7	.....	0	1	5,480	4,560	1,068	206	.....	.....	1	3	8	1	.....	T. C.	No apparent cause.
		14	42	15.3	26.8	17.7	.....	0	1	4,950	.....	.....	184	.....	.....	.....	.....	.....	.....	.....	S. T. C.	Do.
		15	42	15.4	24.8	25.4	.....	0	1	4,750	.....	.....	176	.....	.....	.....	.....	2	.....	.....	T.	Do.
		16	24	15.8	17.3	6.1	.....	0	1	3,320	.....	.....	121	.....	.....	.....	.....	.....	.....	.....	T.	Do.
		17	24	14.8	18.4	9.0	.....	0	1	2,850	.....	.....	101	1	.....	8	1	11	.....	.....	T.	Do.
		18	24	18.6	21.4	16.4	.....	0	1	2,660	2,000	1,140	96	.....	1	1	2	9	6	.....	T.	Irregular grain caused by knot 22 inches from center.
Average				15.9	21.9	15.2	.....	0	.....	4,002	3,280	1,104	147									
Redwood	3 x 14	19	24	12.9	30.0	31.0	.....	0	1	6,530	.....	.....	374	.....	.....	1	.....	.....	.....	.....	T.	No apparent cause.
		20	42	12.9	24.5	23.3	.....	0	1	5,280	.....	.....	306	2	.....	1	.....	18	.....	.....	T.	Do.
		21	42	13.5	25.8	23.4	.....	0	1	5,220	.....	.....	305	.....	.....	.....	.....	15	1	Checks	S. C. T.	Do.
		22	24	13.1	22.3	16.9	.....	0	1	4,520	.....	.....	261	1	1	1	1	5	8	.....	T.	Large corner knot 37 inches from center.

		23	24	13.7	26.2	24.9		0	1	4,370			252	1	1			9		Checks	S. T.	Apparently influenced by checks.
		24	42	12.6	22.8	27.2		0	1	4,280			247		1	2	1	9	10		S.	No apparent cause.
Average				13.1	25.3	24.4		0		5,033			291									
Redwood	2 x 12	25	23	15.5	32.8	14.0		0	1	7,230	4,810	1,303	359				1	4			T.	Do.
		26	24	12.5	20.7	15.7		0	1	5,320	3,340	1,272	254	1		2		11	7		T. C.	Do.
		27	23	15.7	22.4	15.0		0	1	5,050	4,150	1,504	246			2		3	2		T.	Do.
		28	24	13.1	22.5	10.2		0	1	4,590			224					2			T.	Do.
		29	24	12.2	19.8	17.2		0	2	4,490	3,410	918	217			1			1		T.	Do.
Average				13.8	23.6	14.4		0		5,336	3,928	1,249	260									
Redwood	2 x 10	30	24	12.6	25.9	24.5		0	2	6,140			247								T.	Do.
		31	24	12.3	20.6	8.5		0	2	5,000	3,110	1,245	200			6		14	3		T.	Do.
		32	23	16.1	24.7	50.0		0	1	4,840	4,690	1,651	194			1		8	2		S.	Do.
		33	23	15.7	24.0	24.0		0	1	3,950	3,470	698	162								T.	Do.
		34	24	12.4	21.0	17.0		0	2	3,100			126			6		3	2		S. C. T.	Do.
Average				13.8	23.2	24.8		0		4,606	3,757	1,198	186									
Redwood	2 x 8	35	24	12.4	25.3	24.2		0	2	6,680	5,070	1,737	219			3	1	3			T. S.	Do.
		36	24	12.4	22.7	8.1		0	2	5,950	4,210	1,189	192			1		1			T.	Do.
		37	23	15.0	21.4	17.0		0	2	5,080	3,570	1,292	172	1				3	2		T.	Irregular grain caused by knots.
		38	23	15.0	25.9	32.0		0	1	4,900	4,340	963	163			2	1		1		T.	No apparent cause.
		39	23	15.3	24.4	28.0		0	2	4,800	4,380	1,385	157								T.	Do.
		40	24	12.0	22.2	15.0		0	2	2,890			94	2			3	6	5		T.	Small knot on lower face 6 inches from center.
Average				13.7	23.6	20.7		0		5,050	4,314	1,313	166									
Norway pine	6 x 12	1	8	17.0	26.7	7.4		5	3	5,300	2,330	778	289	5		6		27	8	Checks	C. T.	Small knot at center of top face.
		2	8	16.3	26.8	7.5		20	3	5,290	2,630	1,305	293	3	1			15	12	do	T.	Large knot at center of bottom face.
		3	8	19.5	25.7	5.4		10	3	5,240	3,170	1,083	291	3	3	3	1	12	13	do	C. T.	Small knot on top face.
		4	8	15.1	26.4	10.9		5	3	5,190	3,580	1,246	287	3	2		1	16	4	do	T.	Large corner knot 8 inches from center.
		5	8	15.7	26.0	9.4		20	3	5,000	3,130	1,202	271	4			1	21	12	do	T.	No apparent cause.
Average				16.7	26.3	8.1		12		5,204	2,968	1,123	286									
Norway pine	x 10	6	8	13.0	27.3	12.2		30	3	7,860	5,960	1,712	362	3	1			24	1	do	C. T.	Do.
		7	8	13.5	26.9	13.2		25	3	7,810	6,210	1,590	358			1		36			C. T.	Do.
		8	8	13.8	29.0	10.4		40	3	7,620	6,140	1,880	351	2				7	2		C. T.	Do.
		9	8	14.5	28.9	13.1		5	3	5,990	4,210	2,000	278					6	2	Checks	S.	Due to checks.
		10	8	13.8	27.9	11.0		10	3	5,240	3,330	1,380	236			4		20	3		C. T.	Small rotten knot on top face 14 inches from center.
Average				13.7	28.0	12.0		22		6,904	5,170	1,712	317									

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